THE
POPULAR SCIENCE
MONTHLY.

FEBRUARY, 1902.

STELLAR EVOLUTION IN THE LIGHT OF RECENT RESEARCH.*

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MANY attempts have been made to sum up the work of the nineteenth century, and to define its principal lines of progress. In estimates of the relative importance of the books published during this period there has been some divergence of view, but regarding one of them no element of doubt seems to have entered the minds of the critics. By unanimous consent Darwin's 'Origin of Species' is accorded a commanding position among the works which have influenced the intellectual life of the century. It would be difficult to overestimate the effect which the doctrine of evolution has wrought. The principle of orderly and harmonious development which it embodies has found application, not only in explaining the wide diversity of organic species, but in unifying the events of history, in elucidating the origin of language, and in throwing light on difficult questions in every department of human knowledge. The idea of evolution may indeed be traced back through the writings of many centuries. The early philosophers, though not possessed of the immense collection of recorded phenomena by which modern men of science may test their theories, were constantly occupied with great problems demanding the widest generalization. In attempting to account for the earth and its inhabitants they made the first steps in the direction which Darwin subsequently pursued.

* Revised from an address delivered on June 5, 1901, before the Minnesota Chapter of the Honorary Scientific Society of Sigma XI, University of Minnesota.

It would be interesting to recall the strange traditions in which primitive peoples have recorded their vague imaginings of the origin of things. But the absence of even an attempt at careful reasoning renders such tales of no value for our present purpose. The Greek philosophers were not oblivious to the value of observation as a check on speculation regarding the solar system, but the instruments then available were too crude to give accurate positions of the heavenly bodies. Even Copernicus, though he established the sun at the center of our system, and thus paved the way for the nebular hypothesis, retained the epicycles of the Greeks. Kepler, basing his investigations upon the observations of Tycho Brahe, proved that the planets move in ellipses with the sun at the focus, and removed all vestige of doubt as to the general plan of the solar system. The harmony which characterizes the motions of the planets and a knowledge of the effect of gravitation led Kant to formulate an explanation of the origin of the solar system, which subsequently found more perfect expression in the nebular hypothesis of Laplace.

In this hypothesis Laplace seeks to account for the formation of the sun and planets through the contraction of a vast nebulous cloud, which once filled the entire solar system, extending to the orbit of Neptune. This mass, which he considered to be fiery hot, was supposed to be in rotation. As it cooled, through radiation into space, it contracted toward the center. The result of this contraction was to increase the velocity of rotation, and when through increasing velocity the centrifugal force at the periphery counterbalanced the attraction of the central mass, a ring was thrown off. Further contraction resulted in the formation of other rings, in each of which the matter collected about its densest part, and thus produced a planet. Before they had time to cool these planets in turn threw off rings, which, with the single exception of Saturn's ring system, condensed into satellites.

This celebrated hypothesis, though unsupported by mathematical proof, has occupied a dominant position since the time of its publication more than a century ago. It has been subjected to much criticism, but most of the objections raised by Faye and others have been met by modifications of the hypothesis. Of late it has encountered fresh attacks on the part of Chamberlin and Moulton, and it now seems doubtful whether it will be possible to overcome their criticisms, which are based on dynamical considerations. It may prove to be sufficient, however, to forsake the lenticular mass of vapor predicated by Laplace in favor of the spiral form which Keeler has shown to characterize so many nebulæ.

The nebular hypothesis seeks to account for a system like our own, wherein a central sun is surrounded by planets and satellites, originally self-luminous, but ultimately cooled to the point where they are lumi-

nous only through reflected light. The stars are so distant from us that any planets which may attend them are beyond the reach of the most powerful telescopes. In some of the planetary and spiral nebulæ, such as the Great Nebula in Andromeda (Fig. 1), we perhaps

FIG. 2.

STAR-TRAILS PHOTOGRAPHED WITH TWO AND ONE-HALF INCH PORTRAIT LENS (RITCHEY).

observe the earlier stages of the process of condensation, but no distinct evidence of progressive change has yet been gathered from telescopic observation. In seeking for evidence of stellar evolution, on a plan comprehensive enough to include a place for every star in the heavens,

we may begin with visual and photographic observations with the telescope. Such remarkable photographs as that of the Andromeda nebula seem to bring us into the very presence of a greater system, more nearly comparable in size with the Milky Way than with the solar system, in the actual process of formation. But on account of the long periods of time, which must elapse before changes in this distant mass may become sufficiently great to be appreciable, and for many other reasons, we could not hope to base a complete scheme of stellar evolution on such photographs alone. Our observational methods must also include the means of solving physical, chemical and gravitational problems as they present themselves, not close at hand in the laboratory, but at inconceivably distant regions of space. For this reason it would have been impossible prior to the invention of the spectroscope to arrange the stars according to any clearly defined system of development. The principal advances which have been made in the study of stellar evolution are therefore confined to the period which has elapsed since the middle of the nineteenth century.

Thus the investigation of stellar evolution has been contemporaneous with the investigation of organic evolution. Indeed, the epoch-making discovery of the chemical composition of the sun by Kirchhoff and Bunsen was made in the year of the publication of the 'Origin of Species.' Before this discovery the meaning of spectral lines had been as obscure as the meaning of Egyptian hieroglyphs prior to the discovery of the Rosetta stone. After it the chemical analysis of a star became hardly less difficult than the analysis of an unknown substance in the laboratory. Furthermore, it soon became apparent that the light of a star, as decomposed by a prism, was competent to define the star's position in a general scheme of development, in which every advance, from the unformed nebulous cloud on through the highest degree of stellar brilliancy to such a final stage as is typified by the moon, can be defined with but little danger of error. Before we proceed to consider some of the evidences of stellar evolution, let us examine some of the instruments and methods without which the discoveries to be subsequently described would have been impossible.

I shall confine my remarks on modern astrophysical instruments to those at present employed at the Yerkes Observatory, partly because nearly all the celestial photographs reproduced in the figures were taken with these instruments and partly because of the convenience of illustrating them. But before describing the great telescope which forms the principal apparatus of the observatory, I wish to point out that many of the most important results of astronomy, results which could not be obtained with a powerful telescope for the very reason of its great power—have been derived from the use of an ordinary camera, with just such a lens

as is found in the possession of thousands of amateur photographers. If we take an ordinary camera and point it on a clear night toward the north pole, it will be found after an exposure of one or two hours that the stars which lie near the pole have drawn arcs of circles upon the plate (Fig. 2). This is due to the fact that the earth is rotating upon its axis at such a rate as to cause every star in the sky to appear to travel through a complete circle once in twenty-four hours. The nearer the star to the pole the smaller does this circle become. As we move away from the pole we find the curvature of the star trails growing less and less, until at the equator they appear as straight lines.

Just such photographs as these are frequently employed in astronomical investigations; *e. g.*, for the purpose of recording variations in a star's brightness, which would be shown on the plate by changes in the brightness of the trail. But for most purposes it is desirable to have photographs of stars in which they are represented as points of light rather than as lines. To obtain such photographs it is necessary to mount the camera in such a way that it can be turned about an axis parallel to the earth's axis once in twenty-four hours. A camera so mounted becomes an equatorial photographic telescope, differing in no important respect save in the construction of its lens from an instrument like the 40-inch Yerkes telescope.

But the scale of the photographs obtained with such a camera differs in marked degree from that of the photographs furnished by the telescope. Here, for example, is a region of the Milky Way photographed by Professor Barnard with one of the old-fashioned lenses formerly employed in portrait galleries (Fig. 3). Such a picture as this is of the greatest service in all studies of the structure of the Milky Way, for it brings before us at a single glance an immense region of the sky, thus permitting us to trace the general features which are common to this area. You will notice in the midst of this star cloud a little cluster of stars, here so densely packed together that no details of the cluster can be distinguished. If our investigations required us to single out some individual star in the cluster, perhaps for the purpose of analyzing its light, it is evident that the portrait lens would prove inadequate for our purpose. It is in such a case as this that an instrument like the 40-inch telescope comes into play. The camera with which this photograph was taken has a lens six inches in diameter, of thirty-one inches focal length. The great telescope has a lens forty inches in diameter, of sixty-four feet focal length. Thus the scale of the photographs made with the telescope is about twenty-five times that of the photographs made with the portrait lens. The portrait lens covers a large area of the sky on a very small scale, while the field of the telescope is limited to a small region, which is depicted on a large scale. Let us see the difference between the two instruments

as illustrated by the photographs themselves (compare Fig. 3 with Fig. 4). The small cluster, which in reality contains several thousands of stars, is resolved by Mr. Ritchey's photograph taken with the large telescope into all its constituent parts, stars less than one second of arc apart being clearly separated on this great scale.

FIG. 3.
STAR CLUSTER MESSIER 11 AND THE SURROUNDING MILKY WAY.
Small scale photograph taken with portrait lens (Barnard). (The cluster, here about one-sixteenth of an inch in diameter, lies just above the middle of the picture.)

Having seen this illustration of the superior power of the large telescope you may perhaps be interested to become more closely acquainted with the instrument itself (Fig. 5). The great weight of the 40-inch lens, amounting with its cell to half a ton, requires that the tube which supports it, here taking the place of the camera box of the previous instrument, shall be of immense rigidity and strength. This

tube, 64 feet in length, is supported at its middle point by the declination axis, which in its turn is carried by the polar axis, adjusted to accurate parallelism with the axis of the earth. By means of driving mechanism in the upper section of the iron column the whole instru-

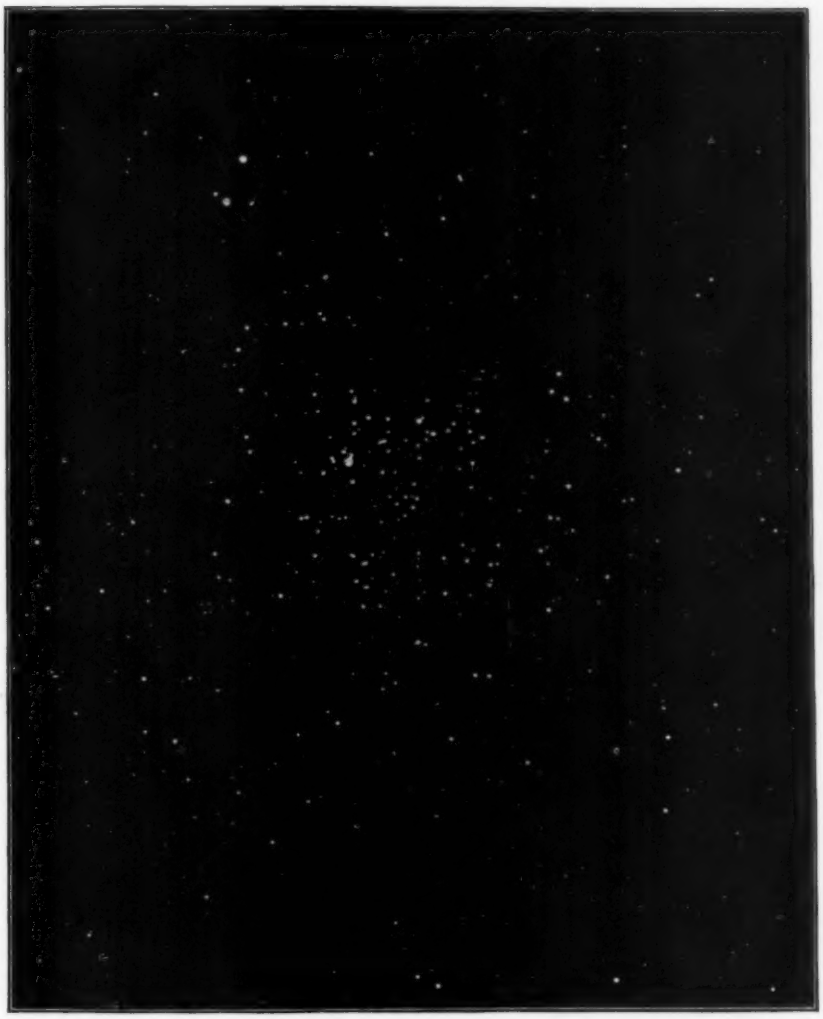


FIG. 4.
STAR CLUSTER MESSIER 11.
Large scale photograph taken with the forty-inch Yerkes telescope (Ritchey).

ment is turned about this polar axis at such a rate that it would complete one revolution in twenty-four hours. Although the moving parts weigh over twenty tons the telescope can be directed to any part of the sky by hand, but this operation is much facilitated by the use of electric

motors provided for the purpose. When once directed toward the object to be observed it will frequently happen that the lower end of the telescope is far out of reach above the observer's head. For this reason the

FIG. 5.
THE FORTY-INCH TELESCOPE OF THE YERKES OBSERVATORY.

entire floor of the observing room, 75 feet in diameter, is constructed like an electric elevator, which by throwing a switch can be made to rise or fall through a distance of twenty-three feet. Thus the lower end of the telescope is rendered accessible even for objects near the

horizon. In order that the observing slit may be directed to any part of the sky the dome, 90 feet in diameter, is mounted on wheels and can be turned to any desired position by means of an electric motor controlled from the rising-floor.

The telescope is used for a great variety of purposes in conjunction with appropriate instruments, which are attached to the lower end of the tube near the point where the image is formed. I have already shown a photograph of a star cluster taken with this telescope, but without describing the process of making it. As a matter of fact the object-glass of the 40-inch telescope was designed for visual observations, and its maker, the late Alvan G. Clark, had no idea that it would ever be employed for photography. Without dwelling upon the distinguishing features of visual and photographic lenses I may say that the former is so designed by the optician as to unite into an image those rays of light, particularly the yellow and the green, to which the eye is most sensitive. With the only varieties of optical glass which can be obtained in large pieces it is impossible to unite in a single clearly defined image all of the red, the yellow, the green, the blue, and the violet rays which reach us from a star. Therefore when the optician decides to produce an image most suitable for eye observations he deliberately discards the blue and violet rays, simply because they are less important to the eye than the yellow and green rays. For this reason the image of a star produced by a large refracting telescope is surrounded by a blue halo containing the rays discarded by the optician. These very rays, however, are the ones to which the ordinary photographic plate is most sensitive; hence in a photographic telescope the blue and violet rays are united, while the yellow and green rays are discarded.

The 40-inch telescope is of the first type, constructed primarily for visual observations. In order to adapt it for photography Mr. G. W. Ritchey of the observatory staff simply places before the (isochromatic) plate a thin screen of yellow glass, which cuts out the blue rays, but allows the yellow and green rays to pass. As isochromatic plates are sensitive to yellow and green light there is no difficulty in securing an image with the rays which the object-glass unites into a perfect image. During the entire time of the exposure a star which lies just outside the region to be photographed is observed through an eye-piece magnifying 1,000 diameters. This eye-piece is attached to the frame which carries the photographic plate, and is susceptible of motion in two directions at right angles to each other. In the center of the eye-piece are two very fine cross-hairs of spider web illuminated by a small incandescent lamp. If the observer notices that through some slight irregularity in the motion of the telescope, or through some change of refraction in the earth's atmosphere, the star image is

moving away from the point of intersection of the cross-hairs, he instantly brings it back by means of one or both of the screws. As the plate moves with the eye-piece it is evident that this method furnishes a means of keeping the star images exactly at the same point on the plate throughout the entire exposure. With such apparatus data are gathered for the study of stellar development.

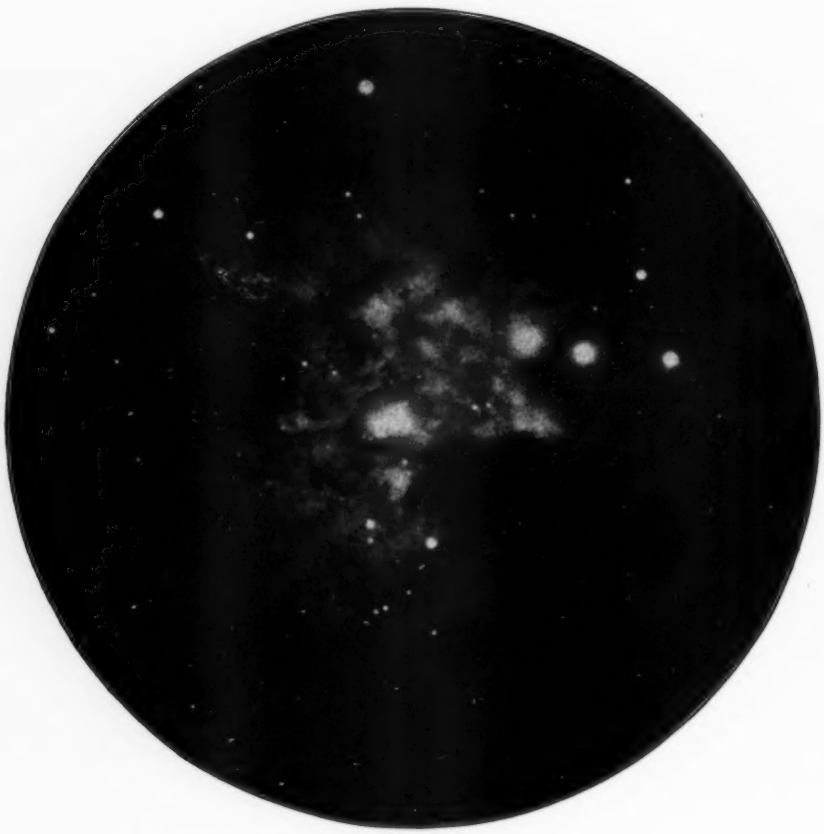


FIG. 6.
GREAT NEBULA IN ORION.
Photographed with the forty-inch Yerkes telescope (Ritchey).

It is easier to trace the successive steps in the development of a star after it has been formed than it is to account for its origin. But all the evidence that has been accumulated up to the present time tends to show that stars are condensed out of the cloudlike masses which we know as nebulæ. Less than half a century has passed since the true nature of a gaseous nebula was determined. In his extensive observations of astronomical phenomena Sir William Herschel examined a great number of star clusters similar to that shown in

Fig. 4. His telescope was a large one, but it can safely be said that he never saw a cluster so well as this object can be perceived through the aid of photography. He found in studying object after object in all parts of the heavens that many clusters could be resolved into their constituent stars. In some of these clusters the stars are widely separated by a powerful instrument, as they appear in this photograph. In others, either on account of their greater distance or because the stars are less widely spaced, the central regions are no longer clearly resolvable as separate objects. It is thus quite possible to imagine a cluster in which the stars are so closely grouped that no telescope, however powerful, could separately distinguish them.

Now as a matter of fact we find in all parts of the heavens luminous objects which can not be separated into stars. Some of these are of definite outline and are perfectly symmetrical in form, in many cases with a brilliant star-like nucleus at their center. These are known as the planetary nebulæ. Other nebulæ, like the great nebula in Orion (Fig. 6), are diffuse and irregular and extend over great regions of the sky. It was long a question whether such objects were capable of resolution into stars with a sufficiently powerful telescope. Herschel rightly concluded that an important distinction can be drawn between a nebula and a star cluster, though his son did not admit this distinction.

It was only after Huggins had applied the spectroscope to an analysis of the light of a nebula that it could be said without danger of contradiction that the phenomenon is not one produced by the crowding together of separate stars, but is due to the presence of a mass of incandescent gas. Sir William Huggins' account of his first spectroscopic examination of a nebula is recorded in the first volume of the 'Publications of the Tulse Hill Observatory':

"On the evening of August 29, 1864, I directed the spectroscope for the first time to a planetary nebula in Draco. I looked into the spectroscope. No spectrum such as I had expected! A single bright line only! At first I suspected some displacement of the prism, and that I was looking at a reflection of the illuminated slit from one of its faces. This thought was scarcely more than momentary; then the true interpretation flashed upon me. The light of the nebula was monochromatic and so, unlike any other light I had as yet subjected to prismatic examination, could not be extended out to form a complete spectrum. After passing through the two prisms it remained concentrated into a single bright line, having a width corresponding to the width of the slit, and occupying in the instrument a position at that part of the spectrum to which its light belongs in refrangibility. A little closer looking showed two other bright lines on the side towards the blue, all three lines being separated by intervals relatively dark. The riddle

of the nebulæ was solved. The answer, which had come to us in the light itself, read: Not an aggregation of stars, but a luminous gas."

With this advance a new era of progress began. The power of the spectroscope to distinguish between a glowing gas and a mass of partially condensed vapors like a star established it at once in its place as the chief instrument of the student of stellar evolution. It became apparent that the unformed nebula might furnish the stuff from which stars are made. Observations tending to this conclusion were not long in presenting themselves. In the heart of the Orion nebula are four small stars which constitute the well-known Trapezium. Situated as they are in the midst of this far-reaching mass of gas, it is not hard to picture them as centers of condensation, toward which the play of gravitational forces tends to concentrate the gases of the nebula. It might therefore be expected that stars in this early stage of growth should show through the spectroscopic analysis of their light some evidence of relationship with the surrounding nebula. Now this is precisely what the spectroscope has demonstrated. Not only these stars, but many other stars in the constellation of Orion, are shown by the spectroscope to contain the same gases which constitute the nebula. For this and other reasons they are considered to represent one of the earliest stages of stellar growth.

It may be many years before the exact nature of the process by which a star is formed from a nebulous mass is clearly understood. Shortly before his death the late Professor Keeler made a most important discovery in the course of his photographic work with the Crossley reflector of the Lick Observatory. Spiral nebulæ have long been known, but it was not supposed that they were sufficiently numerous to be regarded as type objects. The great spiral nebula illustrated in Fig. 7 from one of Mr. Ritchey's recent reflector photographs has long been regarded as one of the most remarkable objects in the heavens, and the possible significance of its form had by no means been overlooked. But few astronomers were prepared for Professor Keeler's announcement that the majority of nebulæ are of the spiral form and that many thousands of these objects are within the reach of such an instrument as the Crossley reflector. It does not seem improbable that this spiral form may prove to represent the original condensing mass more truly than the lenticular form from which Laplace imagined the solar system to be evolved.

Enough has already been said to indicate how large a part the methods of spectroscopy must play in a study of the life history of stars. In spite of the common opinion that the spectroscope is an intricate instrument and that the principles of spectroscopy are obscure and difficult of comprehension, it is a fact that the processes used in this field of investigation can be easily understood by any one who will

devote a very small amount of time to the subject. As you doubtless know, the essential feature of a star spectroscope is the prism or train of prisms by which the star light is divided into its constituent parts. After passing through the prisms the light of the star is spread out into a long band, which shows all the colors of the rainbow, beginning

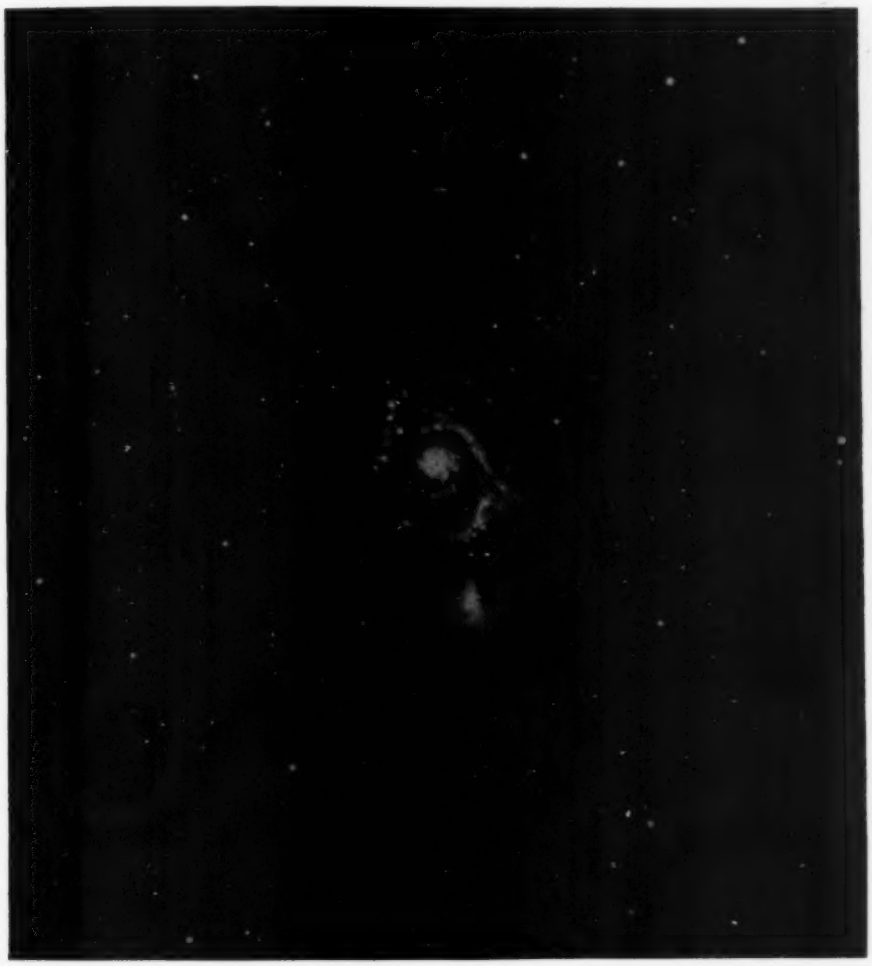


FIG. 7.
SPIRAL NEBULA IN CANES VENATICI.
Photographed with the two-foot reflecting telescope of the Yerkes Observatory (Ritchey).

with red at one end and passing through orange, yellow, green and blue, to violet at the other. This band is crossed by lines, and the problem of the spectroscopist is to interpret the meaning of these lines. If the lines are dark he knows that the light of the star after originat-

ing in an interior incandescent body has passed through a mass of cooler vapors, and that during its transmission some of the light has suffered absorption. If, on the other hand, the lines are bright, he knows that the region where they are produced is hotter than that lying below. Thus a single glance at the spectrum of a star is sufficient to give important information regarding the physical condition of its atmosphere.

But the spectral lines are able to tell a far more complete story of stellar conditions. If their exact position in the spectrum can be measured it becomes possible to determine the chemical composition of the star's atmosphere. And here the spectroscopist may be said to have the advantage of the archeologist, in that the key to stellar hieroglyphs is a master key, capable of interpreting not merely the language of a single people or a single age, but of laying bare the secrets of the most distant portions of the universe and applying with equal force to the primitive and to the most highly developed forms of celestial phenomena. If we take a piece of iron wire and turn it into vapor in the intense heat of an electric arc lamp we find that the light which the glowing iron vapor emits, when spread out into a spectrum by a prism, consists of a series of lines characteristically spaced and always occupying the same relative positions. In the same way every other element when transformed into vapor by a sufficiently intense heat emits characteristic radiations, consisting of groups of lines occupying definite positions in the spectrum. It is thus easy to see how the presence of iron vapor can be detected in the atmosphere of Sirius or in that of the sun. In the spectrum of each of these stars we find a group of lines occupying the same relative positions as the lines furnished by the iron vapor in an electric arc. Hydrogen gives an even more characteristic group of lines, which grow closer and closer together as we pass from the red end of the spectrum toward the violet. This group occurs in the spectra of thousands of stars and serves as an important guide in determining a star's place in a general scheme of stellar evolution.

The practical means of carrying out this method of research may be illustrated by a reference to the stellar spectroscope employed with the 40-inch Yerkes telescope. The spectroscope is rigidly attached to the lower end of the telescope tube. The image of a star formed by the 40-inch lens passes into the spectroscope through a slit about one one-thousandth of an inch wide. After analysis by a train of three prisms an image of the resulting spectrum is formed by a suitable lens upon a photographic plate. In making the photograph it is only necessary to keep the image of a star exactly on the slit throughout the exposure, which may occupy from one minute to several hours, the duration depending upon the brightness of the star.

We have seen that a single glance at the spectrum of a star is sufficient to give us important information as to the structure of its atmosphere, while a study of the position of the lines tells what chemical elements are present. We might go on to consider how the width and sharpness of the lines, together with shifts in their position toward the red end of the spectrum, furnish the means of estimating the density of the vapors and the pressure to which they are subjected. The relative intensities of certain lines also serve as a clue to the temperature. Thus in the spectrum of magnesium there is a pair of lines, one of which is the stronger at the temperature of the electric spark, while the other is the stronger at the lower temperature of the electric arc. In the spectra of certain stars the greater intensity of the first line indicates that the temperature is high and approximates that of the electric spark, while in other stars the relative intensities are reversed, indicating that the temperature is lower and corresponds more closely with that of the electric arc. In addition to all this, certain easily measurable changes in the position of the spectral lines are known from Doppler's principle to indicate motion of the star in the direction of the earth. Thus if the lines are shifted toward the red with reference to their normal position, and if we have evidence that the shift is not due to pressure, we may conclude that the distance between the earth and the star is increasing, while if the lines are shifted toward the violet we conclude that the distance between the earth and the star is decreasing. As the earth's motion is known, the velocity of the star in the line of sight can therefore be accurately determined.

After this glance at the methods employed by the spectroscopist, we may return to a further consideration of the stages of stellar evolution. We have seen that the long continued action of gravity tends to produce condensation of a cosmical cloud. The constellation of Orion contains many examples of stars in this early stage of development. As the mass condenses its temperature rises, and corresponding with this rise in temperature and in the density of the vapors which constitute the star we find characteristic changes in the spectrum and also in the star's color. Such a brilliant white or bluish-white star as Sirius or Vega may be taken as representative of the next stage of stellar development. Here the broad bands of hydrogen, which constitute a beautiful series expressible by a simple mathematical formula, serve as the chief mark of distinction. The conditions are not yet ripe for the marked development of metallic lines, though doubtless the numerous elements which constitute the sun and which for the most part are familiar to us on the earth, are present in such stars, though they are not revealed through a study of the spectrum. It is true that evidence exists of the presence of iron and a few other substances, but the lines are thin and few in number and would be overlooked in a

casual examination of the spectrum. The period for their greatest development has not yet arrived. The light gas hydrogen, reaching far above the white-hot mass of condensed vapors which constitutes the nucleus of the star, is at this stage the predominant element, at least so far as we may judge from a study of the light radiation.

An interesting question has arisen regarding the period in a star's life at which the highest temperature is attained. The apparently paradoxical statement of Lane's law that the temperature of a cooling mass of incandescent vapors, instead of falling, actually increases until a certain stage has passed, applies in the present instance. We indeed know that a condensing nebula losing heat by radiation into space will continue to rise in temperature for thousands and even millions of years. A question which has received some discussion of late is with regard to the precise period at which the maximum temperature occurs. Shall we seek it in white stars like Sirius or in yellow stars like the sun, which represents the next well-defined stage of stellar evolution? With an instrument of extraordinary delicacy Professor Nichols has recently measured at the Yerkes Observatory the amount of heat which we receive from Vega and Arcturus. The distance of these stars is so inconceivably great that the quantity of heat which they send to the surface of the earth has hitherto been too small to be detected by the most sensitive instruments. Professor Nichols' radiometer, which in combination with a large concave mirror renders it easy to measure the heat radiated from a man's face 2,000 feet away, proved adequate for the task. He found that Arcturus sends us about as much heat as we should get from a candle six miles away if there were no intervening atmosphere to reduce the candle's intensity. Vega, which to the eye is precisely equal to Arcturus in brightness, was found to send us only half as much heat. If the absorbing atmospheres of Arcturus and Vega were similar in character, it would follow from Professor Nichols' results that Vega, though it sends us less heat, is really the hotter of the two stars. For we know from laboratory experiments that the proportion of long (heat) waves to short (light) waves is greater in the radiation of the cooler of two bodies heated to incandescence. In this case the fact that Arcturus sends the greater amount of heat would be ascribed rather to greater size than to lesser distance, as there is good reason to believe that it is farther from us than Vega.

But unfortunately the dissimilarity of the atmospheres of the two stars renders it uncertain whether such conclusions can safely be drawn. This is particularly true in view of the fact that Sir William Huggins concludes from his spectroscopic studies that the highest stage of stellar temperature is reached in stars like Vega, while stars like Arcturus and the Sun have passed the stage of highest temperature and are already well advanced in their decline.

While some uncertainty must therefore prevail until further investigations have been completed regarding the exact stage at which the highest stellar temperatures are attained, there can be little doubt as to the path which is followed when through the long continued action of gravitation a young star like Vega develops into a star like the Sun. We are fortunate in possessing examples of a great number of intermediate stages in this orderly progress (Fig. 8). As condensation continues, and as the vapors which constitute the star continue to crowd upon each other, the stellar nucleus becomes denser and denser and the vast atmosphere of hydrogen gradually gives place to a much shallower atmosphere, in which hydrogen is still conspicuous, though it no longer predominates in a very striking manner over the other elements. The spectral lines of such elements as iron, magnesium, sodium and cal-

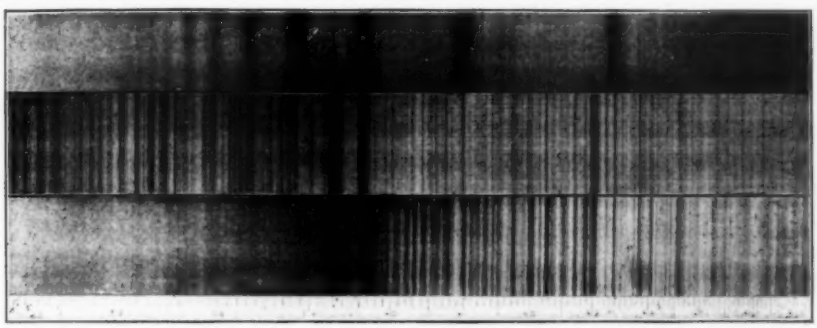


FIG. 8.

CHARACTERISTIC SPECTRA OF (*a*) WHITE, (*b*) YELLOW, AND (*c*) RED STARS (HUGGINS).

cium, rise into prominence as the hydrogen lines fade. Meanwhile the light of the star undergoes a change of color, completely losing its bluish cast and assuming a distinctly yellow hue. There can be little if any doubt that our own sun once passed through the successive stages which are represented by the spectra shown in Fig. 8. The time which has elapsed since it acquired its present size and density as the result of the condensation of the great nebula in which the earth and the other planets also had their origin, covers many millions of years. It is fortunate for the study of stellar evolution that the stages through which the sun once passed are all exemplified in existing stars, which for unknown reasons began their stellar life at widely different times.

It will be profitable to consider for a moment some of the remarkable phenomena which are presented to us by the sun, not only because of their intrinsic interest, but also because it is perfectly safe to assume that similar phenomena, sometimes on a much greater scale, would be presented by other stars, were they not at so great a distance from the earth as to reduce them to mere points of light, even in the most power-

ful telescope. The sun has a diameter of 860,000 miles and, as its distance from the earth is only 93,000,000 miles, an extremely small fraction of the distance of the other stars, it is possible to observe and to study in detail its extraordinary phenomena, which are incomparably more violent than anything observed on the earth. When we speak of the sun we speak collectively of a great number of phenomena, some of which extend for millions of miles from the sun's visible disk. Chief of these is the corona, a vast filmy atmosphere so rare that it offers little or no resistance to the passage of a comet, as it sweeps around the sun under the action of gravitation and returns into the space from which it came. The polar streamers of the corona (Fig. 9) suggest the

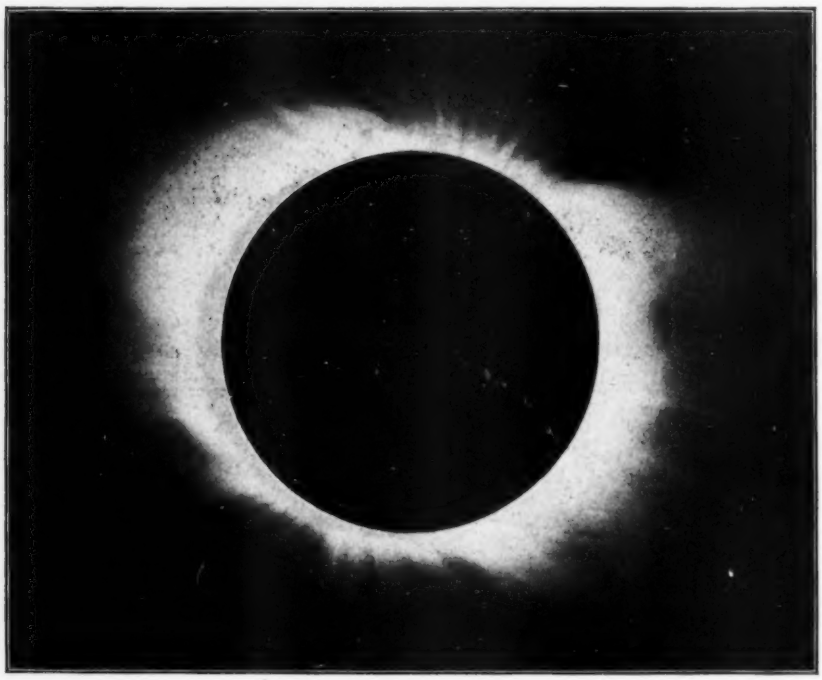


FIG. 9. THE SOLAR CORONA.
Photographed by Yerkes Observatory Eclipse Expedition, May 28, 1900 (Barnard and Ritchey).

action of magnetic forces and offer material for long continued study of this, the most mysterious of all the solar appendages. At the base of the corona, rising out of a sea of flame which completely encircles the sun, are the prominences, some of which occasionally attain a height of nearly 400,000 miles. Like the corona, the prominences are hidden by the brilliant illumination of our own atmosphere, and are visible to the naked eye only when the direct light of the sun's disk is cut off by

the interposition of the moon at a total eclipse. But methods have been devised by which they can be observed or photographed on any clear day through the agency of a modified form of spectroscope. The prominences are constantly changing in form, sometimes slowly, as in the case of this group (Fig. 10), a photograph of which, taken at the eclipse of May 28, 1900, by the Astronomer Royal of England in Spain, is shown for comparison with the photograph taken about two hours earlier by the Yerkes Observatory party in North Carolina. Here the

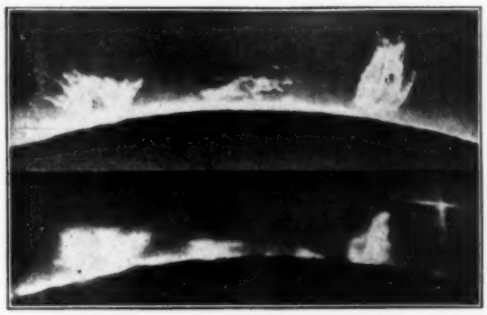


FIG. 10.

CLOUD-LIKE PROMINENCES PHOTOGRAPHED AT THE ECLIPSE OF MAY 28, 1900. *a*, BY YERKES OBSERVATORY PARTY AT WADESBORO, N. C. *b*, BY ASTRONOMER ROYAL OF ENGLAND AT OVAR, PORTUGAL, TWO HOURS LATER. (THE BRIGHT CROSS ON THE RIGHT OF THIS PICTURE IS DUE TO A DEFECT IN THE ORIGINAL PHOTOGRAPH.)

change in the form of the mass of gas which constitutes the prominence, is comparatively small, but that violent forces are sometimes at work may be illustrated by photographs of an eruptive prominence taken at the Kenwood Observatory in 1895 (Fig. 11). At the moment when the first photograph was made the prominence had attained a height of 160,000 miles and was rising rapidly. Eighteen minutes later another picture was taken; during the interval the prominence had been going upward at the rate of six thousand miles a minute, and when the exposure was made it had reached an elevation of 280,000 miles. When looked for a few minutes later it had completely disappeared.

The constitution of the chromosphere, the sea of flame some 10,000 miles deep from which the prominences arise, increases in complexity as the surface of the solar disk is approached. In its upper part only the vapor of calcium and the light gases, hydrogen and helium, are found. But in proceeding downward the vapors of magnesium, sodium, iron, chromium, and last of all, carbon, are successively encountered. At this part of the solar atmosphere the dark lines of the solar spectrum take their rise through the effect of absorption.

Time does not permit a detailed description of the phenomena of

the sun's disk. When photographed with an instrument which excludes from the sensitive plate all light except that which is characteristic of the vapor of calcium, its surface is found to be dotted over with extensive luminous regions. Associated with these are the sun-spots, the minute study of which has revealed some strikingly beautiful phenomena, which have been most successfully drawn by Langley. The surface of the sun in the regions devoid of spots is shown by the photographs of Janssen to consist of brilliant granules separated by darker spaces. Much might be said of the peculiar law of rotation of the sun, which causes a point near the equator to complete an axial rotation in much less time than a point nearer the poles. Much might also be said of the periodicity of sun-spots, which at times are

a FIG. 11. *b*

ERUPTIVE PROMINENCE PHOTOGRAPHED IN FULL SUNLIGHT AT THE KENWOOD OBSERVATORY, CHICAGO, MARCH 25, 1895. *a*, AT 10H. 40M. (HEIGHT, 162.000 MILES). *b*, AT 10H. 58M HEIGHT, 281,000 MILES). (FIGS. 10 AND 11 ARE REPRODUCED ON THE SAME SCALE.)

very numerous and again, as at present, are absent from the sun's disk for weeks together. But enough has already been told to indicate some of the chief characteristics of this central star of the solar system, which has thousands of counterparts among other stars of the same spectral class.

We are now approaching the last chapters in the life history of a star. After the solar stage has passed the color changes from yellow to orange, and subsequently to red, as the temperature falls. The spectral lines of hydrogen become fainter and fainter and finally disappear completely. The lines of the metallic elements, on the contrary, become more and more complex and the changes in their relative intensities are those which are characteristic of lower temperatures. But curiously enough,

there are two well-defined classes of these older stars, which until recently were not known to have any points in common except their red color. These are the stars of Secchi's third and fourth types. In general appearance their spectra are wholly unlike, particularly on account of the absence from third class spectra of the broad dark bands due to the absorption of carbon vapor, the most characteristic feature of the fourth type. But in spite of this apparent dissimilarity, photographs recently taken with the 40-inch Yerkes telescope show that in certain regions of the spectrum stars of the two types are practically identical and are thus probably more closely related than formerly appeared to be the

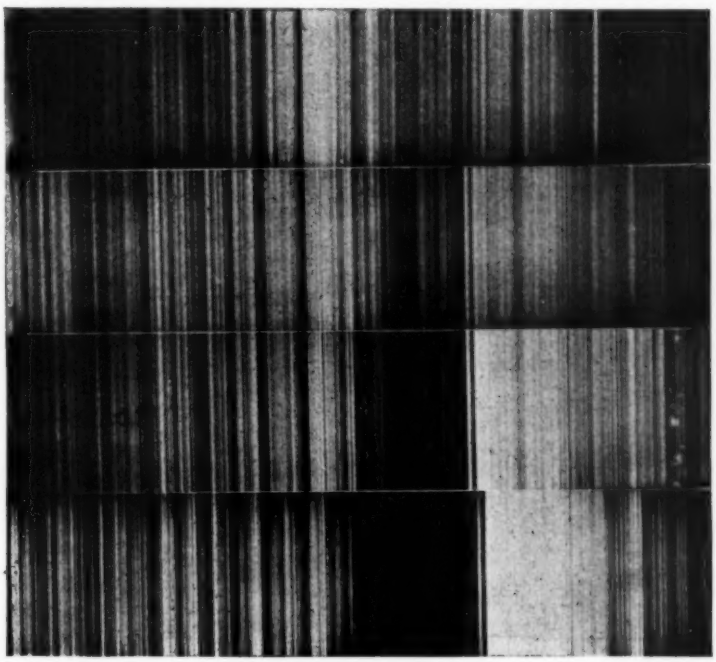


FIG. 12.

SPECTRA OF FOUR RED STARS (HALE AND ELLERMAN). SHOWING HOW THE DARK BAND DUE TO CARBON INCREASES IN INTENSITY AS THE STAR COOLS.

case. The measurements and reductions of a long series of photographs of fourth type spectra now in progress at the Yerkes Observatory should soon permit us to form an opinion of the nature of these interesting stars.

In both the third and fourth types it is easy to trace the successive stages of development. In stars of the fourth type the signs of increasing age are particularly striking. The carbon vapor which produces the broad dark bands becomes denser and denser, until it is not difficult to imagine that through the further increase of such absorption the light of the star might be completely extinguished (Fig. 12).

The phenomena of the red stars indicate that this final stage is close at hand, and curiously enough, in further testimony of the remarkable power of the spectroscope, the total extinction of a star's light does not always prove sufficient to place that star beyond the reach of this instrument. It is true that a spectroscope cannot reveal the chemical composition of a solid body which is devoid of intrinsic light, but such a body may form a system with another object which is still lumin-

FIG. 13.

LUNAR CRATER THEOPHILUS AND SURROUNDING REGION. PHOTOGRAPHED WITH THE FORTY-INCH YERKES TELESCOPE (RITCHEY).

ous, and its gravitational power may cause the luminous body to move in an orbit. As we have already seen, the spectroscope is capable of revealing the motions of such a body. From a knowledge of these motions and the time in which the revolution is effected it is possible to determine the mass and dimensions of the system, and in some special cases like that of Algol, the diameter and density of the invisible component of the pair.

We must look to the solar system for examples of stars in the last stage of development. Each of the planets may in fact be regarded as an object of this kind. The bare and rocky surface of the moon affords a desolate picture of what may result from this long continued process of condensation. The volcanic region which is shown to excellent advantage in a photograph recently taken with the Yerkes telescope, (Fig. 13) gives no evidence of the existence of life; in fact, the spectroscope indicates that if there is any air on the moon it is much too rare to support life as we know it.

Fortunately, the moon is not the only example of a worn-out star. The earth, which probably has many counterparts in the universe, is another example of a less desolate kind. Here, though the process of condensation which is the chief cause of celestial phenomena has ceased, the problem of evolution has not ended. In fact, though the cosmical problems which we have considered in their barest elements will not be completely solved for centuries, it may be truly said that the questions raised by the countless living organisms in a single drop of ditch water are still more complex, and will require a still longer time for their solution.

WINGED REPTILES.

By Professor S. W. WILLISTON,
UNIVERSITY OF KANSAS.

OF the cold-blooded, air-breathing animals known as true reptiles there are now in existence upon the globe more than four thousand species, classified by naturalists in four very distinct groups or orders—the Rhynchocephalia, Crocodilia, Chelonia and Squamata. Of the Rhynchocephalia, there is but a single species now living, the Tuatera or Sphenodon, confined to the islands off the northeast of New Zealand, and very rare. It is a small animal, seldom attaining a length of twenty inches, lizard-like in habits and appearance. Though now so near extinction, the order during Paleozoic times was an important one, both in size and variety. No older reptiles are known.

The Crocodilia, inclusive of the alligators and gavials (better garials) number at the present time scarcely twenty-five species, confined to tropical and subtropical shores of both the old and the new worlds. Of great size, cruel and sluggish in disposition, they seem to be a reminder of those times when size, rapacity and cruelty characterized their class on land, in the air and in the water. Though approaching extinction, these modern representatives of what was at one time a far more numerous and widely distributed order are the specialized descendants of an ancestral line scarcely less ancient than the rhynchocephalian. In form and size, and probably also in habits, the crocodilia have varied comparatively little throughout the greater part of their long period of existence upon the earth.

Were none of the Chelonians—the tortoises and turtles—now living, the extinct forms would appear to us among the most remarkable of vertebrate animals, so little interest do familiar things incite. Like the crocodilia and rhynchocephalia, they are among the oldest of reptiles; yet in number and variety at the present time they are inferior only to the lizards and snakes, and may truly be said, after the lapse of many millions of years, to be only now at or but recently past the zenith of their development. In the past there have been species perhaps twice or thrice as large as any now in existence—from the Bad Lands of Dakota there is known one sea-turtle twelve or more feet in expanse of shell, with a skull nearly as large as that of a horse—but in type of structure the very oldest that we know differed but slightly from some that are now living.

On the other hand, the Squamata (so called because of the scaly covering which characterizes them) are the most modern of all reptiles. They number now more than thirty-four hundred species, about equally divided between the lizards and snakes, the only modern representatives of the order. In the remote past so far as we can trace the broken line of descent, the ancestral forms had but a single conspicuous offset, the rapacious mosasaurs, which had, however, a comparatively brief existence. The lizards, like the snakes, probably go back little or no further than the Age of Mammals. They are, with few exceptions, terrestrial animals of small size and inoffensive habits; the largest living examples scarcely exceed six feet in length, though within the period of man's existence there have been lizards five or six times as long.

Snakes or serpents, the latest, and in many respects the most specialized, of all reptiles, have not yet reached the culmination of their development, a statement which perhaps may not be truthfully made of any other group of reptiles. Their geological history is insignificant and scanty. The venomous serpents especially present the latest modifications of reptilian structure, perhaps the very latest antecedent to the final extinction of the whole class.

No reptiles at the present time walk erect, as did many of the extinct kinds. Their progression is essentially a crawling one, their legs, when present, serving more for propulsion than support. The only exceptions to strictly arboreal, terrestrial or aquatic habits among living reptiles are found in the curious and beautiful little flying lizards, or 'flying dragons,' of the Malayan region. In these reptiles, the flattened body is provided with a broad, wing-like expansion of the skin of its sides, supported by the elongate, movable ribs, and capable of being folded up, fan-like. Similar membranous expansions are also found on the sides of the throat. By these means the creature, which lives for the most part among the tree tops, rarely descending to the ground, is capable of certain aerial movements, though not of true flight. In describing its habits a writer has said: "As the lizard lies in shade along the trunk of a tree, its colors at a distance appear like a mixture of brown and gray and render it scarcely distinguishable from the bark. There it remains with no sign of life, except the restless eyes, watching passing insects, which, suddenly expanding its wings, it seizes with a sometimes considerable, unerring leap." Their flight through the air is very swift, so swift that the expansion of the parachute-like membrane may almost escape notice. As in the flying fishes, flying lemurs and flying squirrels, there is not true flight—a power possessed by no living back-boned animals except birds and bats.

Altogether the direct antecedents of the reptiles now living, that is the crocodiles, turtles, lizards and snakes of the past, took no important part in the great Age of Reptiles. They have existed all these millions

of years, some of them at least, because of their comparative insignificance among their many powerful relatives. Of these relatives, the huge dinosaurs, the swimming ichthyosaurs, plesiosaurs and mosasaurs, and the flying ornithosaurs, with others scarcely less renowned in geological history, are known only from the scanty records of the rocks.

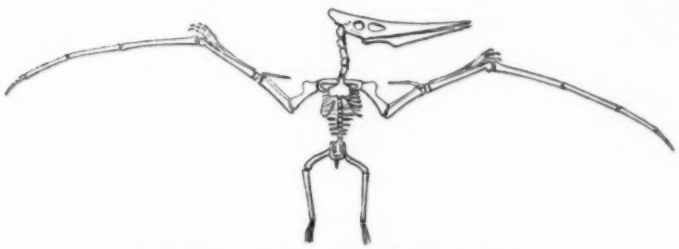
Of all the reptiles of the past, perhaps the most extraordinary, the ones which departed most from the reptilian type in form and habits, as well as the most highly specialized of all cold-blooded animals of the past or present, were the ornithosaurs or pterodactyls. They made their appearance in geological history, so far as is known, suddenly and in a highly developed state; we know nothing of their antecedents, nor indeed of their descendants. They flourished through millions of years in great numbers and multitudinous forms, and then, evidently, as suddenly disappeared. So different were these flying creatures from any others of the past or present that their proper place in the animal kingdom has been disputed. They were at first thought to be birds, and so described; and this idea of their relationship found expression in the name by which they are more properly known, the ornithosaurs or bird-reptiles. Some authorities would even yet give them a place all their own among animals, coordinate with the birds and reptiles. But they are now so well known to students of extinct life, and in so many forms, that there can scarcely be longer a serious question of their real, though highly modified, reptilian affinities. It is not impossible, however, though somewhat improbable, that they were, unlike others of their class, warm-blooded animals; it is at least highly probable that their circulatory and respiratory systems reached a much higher degree of perfection than is the case in any cold-blooded animals of the present time.

RESTORATION OF PTERANODON (ORNITHOSTOMA). EXPANSE OF WINGS, NINETEEN FEET, SIX INCHES.

As flying organisms they attained the highest degree of specialization that has ever been reached among animals with a back-bone, at least so far as their skeleton was concerned. Some of them, indeed, seem to have nearly lost all other powers of locomotion—they could move through the air only. Furthermore, the relative proportion between volant surface and body-weight in some of these pterodactyls has been

excelled only among insects. They were, *par excellence,* organisms of flight, to which function all else, so far as was compatible with existence, was subservient.

It was only among the later geological forms, however, that this flight specialization was carried to its extreme, a fact which has its parallel in not a few other classes of animals, where it has been only in

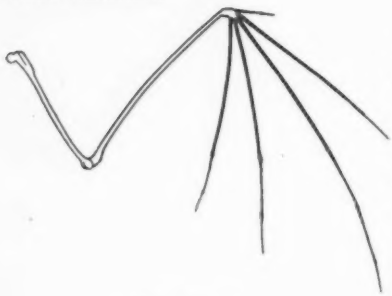


SKELETON OF PTERANODON (ORNITHOSTOMA).

the last bitter struggles for existence that the evolution of the type has been carried to its uttermost. In the accompanying figure is given a restoration of Pteranodon, one of these most highly specialized pterodactyls, based upon skeletons from the Cretaceous chalk of western Kansas. As in all restorations of extinct animals which departed widely from any now in existence, entire truthfulness of expression and appearance can not be expected. A more or less close approximation to the living picture is, however, assured from a complete knowledge of the skeleton and the impression in the rocks of form and of membranes, which have been preserved with the bones of allied forms. I use the more widely known name Pteranodon for this animal, though I believe it to be identical with the European genus previously called Ornithostoma.

The body of Pteranodon was short and relatively small; the legs were slender and weak, and loosely jointed; the toes were small and delicate, with little or no grasping power, and without claws; the tail was rudimentary. As if in compensation for the greatly reduced posterior part of the body, the whole anterior part—the head, neck, thorax and anterior limbs—was extraordinarily developed. The head was slender and elongate, with a dagger-like beak, possibly covered with a horny sheath, and the jaws were wholly toothless. In the largest species the head measured over four feet in length, and its equilibrium was maintained by a strange prolongation backward of the skull. The nostrils were placed far back, and the eyes were protected by a ring of bony plates, similar to those of the eyes of hawks and owls. The neck was long and strong, and very flexible, with a remarkable series of additional articulations unlike anything found in the neck bones of other animals, whereby the thrusting and striking power of the beak was greatly intensified.

But it was in the fore limbs and their attachments that the remarkable adaptation for flight of these animals is found. The shoulder-blade and coracoid, functionally replacing the collar-bone of many animals, were fused together into a stout curved bone, articulating in front with the broad breast-bone and behind with the spines of several fused back-bones or vertebrae. These two shoulder bones thus formed a complete, stout ring, firmly attached in front and behind. Such a mode of articulation of these bones is found in no other animal. To add further to the strength and rigidity of the thorax, the strong upper ribs were not movably articulated, but coossified with the vertebrae. Altogether, the large and broad breast-bone, the complete shoulder-ring, the rigidly fixed upper ribs and the immovable vertebrae furnished a support for the attachment of the enormous wing and its necessary muscles that has no parallel for strength among other animals.



WING OF BAT.

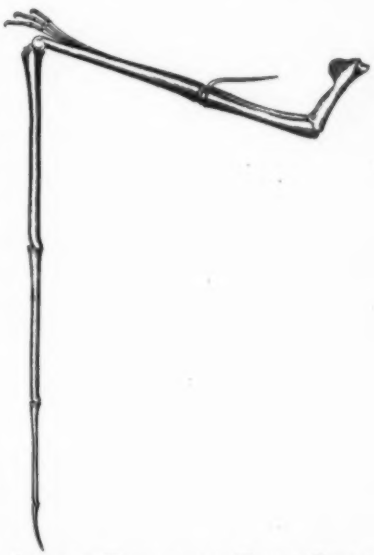
Among the higher animals there are three types of structure whereby the fore limbs are modified into organs of flight. In birds, the arm and fore-arm bones are elongated and strengthened; the bones of the wrist are fused together or wanting, while the few bones of the fingers are welded together and made to hinge sideways. In the bat, among mammals, all the bones, save those of the wrist, are elongated and slender. The very slender fingers are spread out fan-like laterally to support the membrane which replaces the feathers of the bird.

In the pterodactyls, the volant surface, as in the bats, was presented by a thin membrane, which extended from the fore limb to the sides of the body. The bones of the arm were strong, with strong projections for the attachment of muscles; those of the wrist were few in number and closely united. The rudimentary first finger, or thumb, consisting of a single slender bone, was turned backward toward the shoulder for the support of the membrane in front of the elbow. The second, third and fourth fingers were entire, but very small and slender, and were provided at their extremities with very sharp and strongly curved claws. While these fingers were flexible and prehensile, their small size and weakness of attachment (they did not articulate with the wrist) suggest that their only use was for clinging. In strange contrast with these small fingers, the fifth digit, that is the one corresponding to the little finger of the human hand, was enormously elongated and strong, including by far the largest bones of the entire skeleton. Between

its first and second bones there was a marvelously perfect pulley-like joint, permitting the flexion of the finger through an arc of nearly one hundred and eighty degrees. When not in use in support of the wing membrane, the finger could have been folded back close to the arm, touching each other nearly on the back. In fact these bones have been found fossilized in this position.

Attached to the whole length of the arm and finger to its curved extremity, there was a thin, and certainly strong, membrane, which continued on the sides of the body and legs, probably quite to the rudimentary feet. Impressions of this membrane have been found, showing every fold and crease, as though cast in plaster-of-paris.

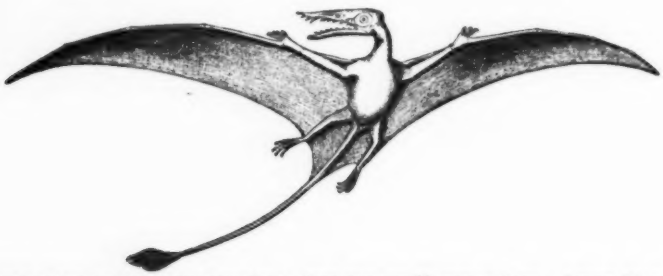
In size these highly specialized pterodactyls reached, as outspread in flight, the enormous expanse of more than nineteen feet from tip to tip of fingers. The length of the body from tip of bill to toes was about eight feet of which the head was nearly a half. Contemporaneous with these gigantic species were many others of smaller size, while related forms of an earlier period scarcely exceeded the stature of a common sparrow.



ANTERIOR EXTREMITY OF WING OF PTERANODON, NINE FEET IN LENGTH.

The earlier pterodactyls were smaller and in many other respects much less specialized than the latter ones, that is they departed less widely from the true reptilian type. Of these perhaps the best known is the Rhamphorhynchus, a restoration of which is given herewith, based upon a nearly complete skeleton in the Yale Museum, a specimen of great interest, because it shows so clearly the impressions of the wing membrane, wholly without hair, feathers or scales. In this pterodactyl, the jaws were provided with long and sharp teeth, the neck was less stout, the shoulders were loosely articulated, the bones of the wings less elongated, the legs stouter. Furthermore, it had a long, slender and flexible tail, provided at its extremity with a diamond-shaped membranous expansion, which doubtless served as a steering organ or rudder in flight. Between the Rhamphorhynchus and Pteranodon there were many intermediate forms, both large and small, with and without teeth. Species of Ornithocheirus, nearly as large as those of Pteranodon, which they closely resembled, except in the presence

of teeth, are known from the chalk of England. Rhamphorhynchus and the still earlier Dimorphodon, as well as the later Pterodactylus are from the Jurassic deposits of England.



RESTORATION OF RHAMPHORHYNCUS. ONE-EIGHTH NATURAL SIZE. AFTER MARSH.

That the Pteranodon had a marvelous capacity for flight, there can be hardly a question. Their remains are often found in the Kansas marine chalk deposits associated with others of deep-sea animals, and many miles away from the ancient shore lines; found so completely preserved that they never could have drifted far. With their remains have been found the fossilized stomach contents, including comminuted fish bones and scales. The bones of their skeletons were

VIEW OF CRETACEOUS CHALK DEPOSITS OF WESTERN KANSAS.

very hollow and light, perhaps more so than in any other animals that have ever lived; so light indeed that a finger bone twenty-six inches in length might be best likened to a hollow cylinder of blotting paper

two inches in diameter; and this hollowness extended into nearly every bone of the skeleton, from the toes to the ribs and the skull. Moreover, the bones were all of fine and firm texture, and the sutures or immovable joints throughout the body were fused or anchylosed, as is the case with birds, thus giving the maximum of strength with the minimum of weight. The larger bones had each one or two pneumatic openings in them, through which doubtless entered ramifications of the bronchial tubes, as in birds.

Altogether the weight of a Pteranodon of the largest size in life could scarcely have reached twenty-five pounds—the bones of the skeleton having an expanse of twenty feet, even as petrified, do not weigh more than five or six pounds. This extreme lightness, together with the vast expansion of the volant membranes, suggests as a comparison the hull and sails of a Columbia or Shamrock. With the perfect and delicate construction and their strong articulations, the fusion of all loose bones, the presence of sclerotic plates in the eyes giving greater control over vision in high altitudes and in the dark, the possession of a relatively large and bird-like brain, all conclusively demonstrate the flight powers of these singular reptiles.

Upon land even the best of the pterodactyls must have been awkward and ungainly, creeping about upon hands and feet, impeded by the cumbersome head and flapping membranes. It is doubtful, indeed, whether the more highly specialized forms like Pteranodon often voluntarily sought the surface of the ground; they doubtless spent the most of the time while not flying, suspended from cliffs and trees by means of their slender, clawed fingers. In the air they reigned supreme and alone, save for the small toothed birds which were then making their appearance in geological history, and which may often have served as delicious tid-bits for their insatiable maws. The sharp, dagger-like beak, driven by the powerful neck, was certainly a murderous weapon against their enemies, whether upon land or in the air. That they laid eggs, like most reptiles, is almost certain. Did they build nests in inaccessible heights?

That the ornithosaurs for a long time enjoyed a wide distribution throughout the world is certain—their remains have been discovered in the most remote parts of the earth, and wherever the conditions were favorable for their existence and the rocks for the represervation of their remains, traces of them may be confidently expected to be found. In North America, with a single exception, their fossilized bones have been discovered only in the Cretaceous deposits of western Kansas. Throughout this region there are wide exposures of pure chalk, the sediment of the old Cretaceous ocean, which at one time extended from the Gulf of Mexico to the Arctic Ocean, and from central Kansas on the east to far into Colorado on the west. Because of the pro-

tected situation of this inland body of salt water, and its placid surface, it was a favorite region for countless and divers animals of strange aspect. The waters swarmed with swimming reptiles of unfamiliar shapes and great size, while over its surface hovered and soared innumerable pterodactyls searching for their prey in the waters beneath. The delicate bones of the pterodactyls, beneath the pressure of the superincumbent rocks, have been, almost invariably, crushed flat, requiring skill and care in their excavation. Sometimes, though rarely, has a skeleton been found nearly complete; more frequently are the scattered bones found here and there. Considering the great buoyancy of their bodies floating upon the surface of the water, or sinking slowly through the ocean's depths, swarming as it was with many predaceous scavengers, one can only wonder that so many have been preserved all these millions of years for the delight and amazement of the modern student of geology.

THE JOURNEYINGS OF BIRDS.

By F. H. KNOWLTON, Ph.D.,
U. S. NATIONAL MUSEUM.

THE sudden appearance of certain familiar birds in spring and their disappearance at the close of summer has excited the attention and interest of all classes of observers from the earliest times. "The stork in the heaven," says the prophet Jeremiah, "knoweth her appointed time; and the turtle and the crane, and the swallow observe the time of their coming." Much curious speculation has been indulged in to account for this periodic appearance and disappearance, one ingenious writer of the early part of the eighteenth century arguing that when the birds leave in the fall they retire to the moon. He presumed that they required about two months in passing thither, and that, after arriving above the lower regions of the air they will have no occasion for food. Concerning the great distance, he adds, 'between the moon and the earth, if any shall still remain unsatisfied, I leave only this to his consideration, whether there may not be some concrete bodies at much less distance than the moon, which may be the recesses of these creatures, and serve for little else but their entertainment,' just as the rocky islands of the sea which he says are 'of no other manifest use than for sea fowl to rest and breed upon!'

Hardly less absurd but wonderfully more persistent has been the notion that birds hibernate during the winter in hollow trees, caves and holes, and, at least in the case of swallows, in the mud at the bottoms of lakes and ponds. Linnæus and Cuvier, as well as a great number of lesser lights, believed that swallows spent the winter in a torpid state in mud, and even as late as 1878, a writer in a prominent natural history journal in this country described the finding, in midwinter, of two swallows in the mud at the bottom of a spring in a logging camp in Maine. When taken out they are said to have revived and to have flown about in a warm room.

These absurd ideas have gradually given way to more rational views, and at the present time the whereabouts of a great majority of our birds is known accurately for the entire year. Their coming and going on these long journeys has been under intelligent, though often desultory, observation for more than a century and, although we have learned much, it seems likely that we are hardly advanced beyond the borderland of this intricate and fascinating subject. The object of the present paper is to bring together some of the more important

and striking of recent results for the purpose of showing that progress, although slow, is actually being made, and also in the hope that it may lead to further observation and record, for which there is undoubtedly abundant need.

In the first place, it may be well to define briefly certain phases of bird movement that are often overlooked or confounded with the generally accepted understanding of what migration covers. In the popular mind, and, it may be added, this is the correct view, a migratory species is one that regularly resorts to a given locality for the purpose of rearing its young, after which both old and young retire to some other, often widely different locality, where they pass the time before the next breeding season. In all temperate countries the migratory birds may be separated along these lines into two classes: first, those which come in spring, spend the summer and retire towards autumn; and second, those which pass through in spring to a breeding ground nearer the pole, and in the fall while on their journey south. The distinction between these two classes is obviously one of degree rather than kind.

The birds that come to us only in winter, such as Juncos, snowflakes, redpolls and Lapland longspurs, are not usually thought of as migrants, yet it requires but a moment's reflection to show that they are strictly so, and this leads to the general proposition that most birds throughout the world are constantly changing their location, but, as the individual is merged in the species, it is often difficult to obtain exact data on the subject. Because we see individuals of a certain species constantly about us, we call that a resident species, but, as a matter of fact, it is more than likely that not the same individuals are continuously under observation.

There is also another class known as occasional visitors, as the pine grosbeak and snowy owl, which may be absent for years, then of a sudden appear in great numbers. Their coming is supposed to be the result of a deficient food supply in their natural habitat far to the north, but the evidence for this is theoretical rather than actual. Hardly to be distinguished from these occasional visitants are the sudden incursions of species in a locality in which they have never been before known, as when a vast horde of nutcrackers spread over all Europe in 1844, or the erratic sand grouse, a bird of Central Asia, which has penetrated to England. But the climax of this restless and roving tendency in birds is reached in the stragglers that now and then are found hundreds, even thousands, of miles away from their homes, as when the Old World skylark is found in Greenland and the Bermudas, the American black-billed cuckoo in Italy, and our catbird and brown thrasher in Europe. While it may not be quite logical to class all these bird movements under the head of migration, as nar-

rowly defined, they are more or less clearly manifestations of the same influences and go to make up the sum total of this wonderful ebb and flow of bird life.

The origin, or perhaps better the origins, of this habit or instinct of bird migration is exceedingly obscure. Many theories have been advanced to account for it, but perhaps none has yet been offered that explains satisfactorily all its multitudinous phases. For instance, it has been suggested that migration is the result of the development or acquirement of the power of flight. That flight has had much to do in making long extended migrations easily possible no one can deny, but that it has been the cause is not logically evident, for certain mammals, as the bison and antelope, are to a limited extent migratory, and certain flightless birds, as the penguins and the great auks, are strictly so, or rather were in the case of the latter species which is now extinct.

According to Mr. F. M. Chapman ('Bird Studies with a Camera,' p. 194) 'the desire for seclusion during the breeding season' is a 'good and sufficient cause for the origin of bird migration.' He applies this theory especially to birds nesting in colonies in secluded spots, as the Ipswich sparrow which is known to nest only on Sable Island, off the Nova Scotia coast, the gannets (*Sula bassana*), which nest in the western hemisphere only on three islets in the Gulf of St. Lawrence, terns on Muskeget and Penikese, and the brown pelicans of the Indian River region of eastern Florida.

This theory may afford an explanation for the migrations of birds that congregate in such colonies during the breeding season, but it should not be overlooked that 'survival of the fittest' may have been an equally important factor in weeding out those individuals of such colonies that did not seek these secluded or isolated localities for breeding sites. These birds may at first have nested in scattered situations and have been driven by predatory animals or other causes to seek inaccessible locations, and seclusion and isolation may thus have been a resultant rather than a cause. It is also difficult to apply this theory to land birds. Take, for example, the warblers of the genus *Dendroica*. Some species barely reach the United States during the nesting season; a few stop in the southern tier of states; others only reach to southern New England, while the bulk of the species press on from northern New England to Hudson's Bay. If seclusion were the only point aimed at, it would seem that the warblers which pass farthest north to breed could have found it in the mountains of the southern and middle states as some now do. Again, certain species, as the cliff and barn swallows, phœbe and summer warbler, seek the vicinity of human habitations during the nesting season, and, moreover, have greatly increased in numbers since the country became thickly settled.

The theory that is, perhaps, most naturally suggested, and the one that finds widest acceptance as explaining the facts is that migration began in a search for food. That is, the food supply becoming short in the vicinity of the home (a bird's home is thus assumed to be the place where it rears its young, and may therefore be quite different from the locality where it spends the remainder of the time) they wandered away in search of food, returning again and again to the home vicinity. These journeys were extended farther and farther, the birds returning each nesting season, undoubtedly oftener at first, to or near the locality where they were born. This process went on until their wandering became a fixed habit, and finally in the countless generations of birds that have come and gone, this habit has been crystallized into what we now call, for want of a better term, the instinct of migration.

This idea has been amplified and extended by Alfred Russell Wallace ('Nature,' X., p. 459). He supposed that 'survival of the fittest' has probably exerted a powerful influence in weeding out certain individuals. He supposed further that breeding can only be safely accomplished as a rule in a given area, and that during a greater part of the rest of the year sufficient food cannot be obtained in that area. "It will follow that those birds which do not leave the breeding area at the proper season will suffer, and ultimately become extinct; which will also be the fate of those which do not leave the feeding area at the proper time." His further argument is ingenious, and, it must be added, extremely plausible. He says: "Now, if we suppose that the two areas were (for some remote ancestor of the existing species) coincident, but by geological and climatic changes gradually diverted from each other, we can easily understand how the habit of incipient and partial migration at the proper seasons would at last become hereditary, and so fixed as to be what we term an instinct."

It will probably be found, however, if anything like a satisfactory explanation can be arrived at, that this habit or instinct has arisen in more than one way, but we may appropriately turn from a consideration of theories to a review of certain observed facts of migration.

It is now abundantly established that migration is mostly carried on at night, and further mainly during clear nights. Only a comparatively few species, such as ducks, cranes, certain large hawks, swallows, swifts, and nighthawks, migrate during the daytime, and these it will be observed, are either rapacious birds or mainly those that enjoy such power of rapid flight as to be relatively safe from capture. All the vast horde of warblers, sparrows, finches, flycatchers, thrushes and woodpeckers, as well as many waders and swimmers, migrate at night. On clear, still nights during the migrations birds may often be heard calling to each other high over head, and, as will be described

later, may be actually seen by powerful telescopes. Woods and hedgerows that were untenanted one day may become fairly alive with birds at daylight the next morning, showing that they have arrived during the night. They remain to feed and rest during the day, and, if the weather be favorable, may practically all disappear the next night. That they only venture on these journeys during clear nights is shown by the fact that on such nights very few birds are killed by lighthouses, monuments or other obstructions, whereas on cloudy or rainy nights, especially such as opened clear and later become overcast, thousands of birds become confused and dash themselves against these obstructions. Thus over 1,500 birds have been found dead at the base of the Bartholdi statue in New York harbor in a single morning, and 230 birds of one species—black-poll warblers—were killed in a single night (Sept. 30, 1883) by the Fire Island light. The Washington monument, although not illuminated at night, causes the death of hundreds of birds annually.

The height above the earth at which migrating birds travel has been made the subject of some interesting observations, the first of which appear to have been by Mr. W. E. D. Scott, on the night of October 19, 1880, at Princeton, New Jersey. In company with a number of visitors he was being shown through the astronomical observatory at that place, and after looking at a number of objects through the 9½-inch equatorial, they were shown the moon, then a few days past its full phase. His attention was at once arrested by numbers of small birds that could be more or less plainly seen passing across the field of observation. Most of the kinds seen were the smaller land birds, among which were plainly recognized warblers, finches, woodpeckers and black-birds. He was able to identify with much certainty the characteristic undulating flight of the goldfinch, and the broad boat-shaped tail of the purple grackle. The flight of the birds noted was apparently nearly at right angles to the field of observation, and they were passing at the rate of 4½ per minute. As nearly as could be estimated their height above the earth was between one and two miles.

In the following year similar observations were made by Scott and Dr. J. A. Allen, but the results were not as striking, only 13 birds passing in any quarter of an hour. They were also apparently flying lower than on the first occasion.

Some years later observations on nocturnal flight were taken up by Mr. Chapman, who spent three hours on the night of September 3, 1887, at Tenafly, New Jersey. During this time 362 birds passed across the moon's face. Of these 233 were computed to be at a height of from 1,500 to 15,100 feet, and curiously the lowest birds seemed to be flying upward, as though they had arisen in the immediate

neighborhood and were seeking the proper elevation at which to continue their flight, but after that time the line of flight was parallel to the earth's surface.' He was able to identify positively only comparatively few species, such as the Carolina rail, grackle and a large snipe.

But perhaps the most satisfactory observations of all were those made also by Chapman, who, in company with a number of ornithologists, spent the night of September 26, 1891, at the Bartholdi Statue, New York. The weather proved to be exceptionably favorable, being clear during the early and later portions of the night, with an intermittent rain storm lasting for three hours between. As early as eight o'clock the birds began to be seen and heard, but almost simultaneously with the beginning of the rain there occurred a very marked increase in the number of birds seen about the light. They came singly, in troops, and in thousands, were visible for a moment and passed on into the darkness beyond. "The birds chirped and called incessantly. Frequently, when few could be seen, hundreds were heard passing in the darkness; the air was filled with the lisping notes of warblers, and the mellow whistle of thrushes and at no time during the night was there perfect silence."

The latest recorded observations were made by Mr. O. G. Libby ('Auk,' XVI., 140), who studied the nocturnal migrations at Madison, Wisconsin, in September, 1897. His first place of observation was a small elevation in the vicinity of three small lakes, where he undertook to make a record of the number of bird calls heard. During the night a total of 3,800 calls were recorded. The number of calls varied greatly, sometimes running as high as two or three per second and again falling to that number per minute. The largest number counted was 936.

From the nature of the data it was manifestly impossible to estimate the number of birds represented by these calls, but the effect was impressive in the extreme. He says: "Nothing but an actual experience of a similar nature can adequately convey the impression produced by such observations. The air seemed at times fairly alive with invisible birds as the calls rang out now faintly and far away, now sharply and near at hand. All varieties of bird calls came sounding out of the darkness that evening. The harsh squawk of a water bird would be followed by the musical *chink* of the bobolink. The fine, shrill notes of the smaller sparrows and warblers were heard only close at hand, but the louder ones came from all along the line, east and west. More than once an entire flock, distinct by the variety of their calls, came into range and passed out of hearing, keeping up their regular formation with the precision of a rapidly moving, but orderly body of horsemen. The great space of air above swarmed with life.

Singly or in groups, large and small, or more seldom in a great throng, the hurrying myriads pressed southward."

The second station chosen by Mr. Libby was the Washburn Observatory, where for three nights he watched the birds passing across the face of the moon. During the three nights a total of 583 birds were counted, the largest number in any fifteen-minute period being 45. Considerable diversity in the direction of flight was noted. Thus up to ten o'clock the prevailing direction was south, but after this time the diversity increased, until it reached its maximum between twelve and two o'clock, when eight principal points of the compass were represented by numbers varying from 3 to 28. However, two-thirds of the number were still maintaining a southerly direction.

Libby attempted to estimate roughly the total number of birds that passed his point of observation during the three nights, but as he well says, 'when one recalls the relatively small size of the moon's surface as compared to its path from east to west, within the range of vision,' the difficulty becomes evident. As nearly as could be made out about 9,000 birds were passing per hour or a grand total of 168,000.

The rate of speed at which birds travel during the migrations, and also at other times, has been made the subject of observation, although the results, as might be expected from the confusing elements which must enter into such an inquiry, are far from complete or satisfactory. If the speed often attained by powerful and swift-flying species, such as ducks, geese, swallows, etc., could be maintained, it is obvious that the time occupied in migrations would be inconsiderable. But, as will be shown later, the maximum speed appears to be rarely or never realized at this time.

Frank Forrester records 90 miles an hour for ducks, as noted by telegraph from point to point, and an albatross has been known to cover 3,150 miles in 12 days. The actual distance flown by the latter bird was probably at least twice as great, for they rarely fly far in a straight line.

Some years ago Griffitt made some observations (recorded in 'The Field,' Feb. 19, 1887) in a closed gallery on the speed attained by 'blue-rock' pigeons and English pheasants and partridges. The two first mentioned flew at the rate of only 32.8 miles per hour, while the partridge made but 28.4 miles, and these rates were all considerably in excess of what they made in the open. The carrier pigeon is a rather fast flying bird, yet the average speed is not very great. Thus the average made in 18 matches ('The Field,' Jan. 22, 1887) was only 36 English miles an hour, although in two of these trials a speed of about 55 miles was maintained for 4 successive hours. In this country the average racing speed is apparently about 35 miles an hour, although a few exceptionally rapid birds have made short distance flight at the

rate of from 45 to 52 miles an hour. The longest recorded flight of a carrier pigeon was from Pensacola, Florida, to Fall River, Mass., an air-line distance of 1,183 miles, made in 15½ days or only about 76 miles a day.

Herr Gätke, whose observations on Heligoland, a small island in the North Sea, extended over a period of fifty years, would give to birds a speed that is incredible. For example, the gray crows were believed by him to pass over the 360 miles between Heligoland and Lincolnshire at a rate of 120 miles an hour, and curlews, godwits and plovers are said by him to cross from Heligoland to the oyster beds lying to the eastward, a distance of a little more than 4 miles, in one minute, or at the astonishing rate of 240 miles an hour. The error in these observations, as suggested by Newton ('Dictionary of Birds,' p. 566), probably lies in the impossibility of identifying the individuals that leave one of the given points with those first arriving at the other end of the line. Professor Newton also calls attention to the fact that few birds, even swallows and quail, fly as fast as an express train from whose windows they may be observed. It is a common experience, when a train is passing along at no great speed, for various birds to be flushed by it, but after flying vigorously for a few hundred yards they quickly drop behind.

But granting that the occasional speed is very considerable, the actual speed of most migrating birds appears to be surprisingly low. Observations tending to prove this were made some years ago under the direction of Prof. W. W. Cook, in the Mississippi Valley. The services of over one hundred observers were enlisted, at stations ranging from the Gulf to Manitoba. The date at which a certain species was first noted at the most southern point was compared with the first appearance of that species at the most northern point; the distance in miles between these two stations is then divided by the number of days between the observations. Thus the Baltimore oriole was first seen at Rodney, Mississippi, April 7, and was not observed at Oak Point, Manitoba, until May 25. The distance in a straight line between these two places is 1,298 miles and as it took 48 days the average speed was 27 miles a day. The records of fifty-eight species for the spring of 1883 gave an average speed of 23 miles a day for an average distance of 420 miles, while in the following year a slightly smaller number of species gave exactly the same average speed over an average distance of 861 miles. In the case of individual species the results were of much interest. Thus the robin, cowbird and yellowhammer traveled at an average speed of about 12 miles a day, while the average for the summer redbird, ruby-throated humming bird and night hawk was 28 miles a day. It is, however, necessary to take so many things into account in arriving at these conclusions that it is easy to see the possi-

bilities of error. For example, meteorological conditions play an important part during migrations, a rain storm or an unusually cold spell may retard progress for days. Even if the conditions are favorable, it is hardly probable that the same individuals migrate for more than a night or two without intermission, so that while the species may be making progress the individuals are alternating a night or two of travel with often several days of rest and recuperation. Again, it was found that most species traveled considerably faster during the latter part of the journey than during the first part. Thus six species showed an increase of 77 per cent. in speed for the northern half of their journey, and the same general result was obtained by calculating the average speed of twenty-five species separately for each of the different months in which migration is performed; the average for March being 19 miles, for April 23 miles and for May 26 miles a day. The species which are late migrants also move faster than those which start earlier and take more time about it.

The persistence with which birds cling to established lines of travel during the migrations is one of the most remarkable facts within the range of bird life, and this in not a few cases can only be interpreted in the light of past geological conditions. Thus certain species which breed in Europe and spend the winter in Africa now cross the Mediterranean at one of the widest points, a seemingly needless waste of energy. But soundings between these points have shown that the sea for much of the distance is relatively shallow, and that a moderate subsidence has changed what may have been narrowest to what is now one of the broadest points. This subsidence was undoubtedly slow and first resulted in the formation of a series of islands and lagoons, and the birds easily passed from one island to another, and even after the last bit of land had disappeared they still followed the old route established by their remote ancestors.

Many shore and water birds that spend the breeding season in and about the arctic circle to the north of Europe and Asia, follow lines of travel during their migrations that were undoubtedly established under past continental or oceanic conditions. Thus certain species take a circuitous route over what is now a wide expanse of open ocean, while others pass far inland through the Russian and Central European lowlands. Those of the first class are simply still following an ancient shoreline, and those of the second class the location of an inland shallow sea.

The Old World migratory quail (*Coturnix coturnix*) is one of the comparatively few migrants among the so-called game birds. During the migrations they wander far from places of their birth, reaching South Africa, Persia and India. The individuals inhabiting Great Britain, or at least a part of them, long ago established a migration

route in a southeasterly direction. When examples from Great Britain were introduced into New England, they adapted themselves readily to their new surroundings and reared young, but when the season for migration arrived the inherited tendency to go in a southeasterly direction asserted itself, and, according to Mr. Wm. Palmer, of the U. S. National Museum, they all passed out into the broad expanse of the Atlantic and were lost.

For several decades it has been noted that a few species of birds from Western Asia have been gradually extending their summer range into northern Scandinavia. When these species migrate, instead of going south through central Scandinavia or southwest along the coast line, as do the original Scandinavian residents, they turn back east to the point in Siberia whence they came, before turning southward to spend the winter on the borders of India.

Forty or more species of migratory birds occur as summer residents in the Yukon Basin, Alaska. Of these some fourteen species are Pacific coast birds. With a single exception they are all thought to reach the upper Yukon by crossing the Alaskan coast range of mountains. This exception, according to Mr. W. H. Osgood, of the U. S. Department of Agriculture, is the varied thrush (*Hesperocichla nævia*), which apparently reaches its summer home by going up the coast to the mouth of the Yukon, and thence following this river for almost 2,000 miles. Equally abundant with it in this summer home is the common snowbird (*Junco hyemalis*) of the eastern United States, which reaches the Yukon Basin by way of the Mississippi Valley.

Perhaps the longest straight-away flight made during the migrations is accomplished by certain shore and water birds, as the tattler (*Heteractitis incanus*), sanderling (*Calidris arenaria*), turnstone (*Arenaria interpres*), and the pintail and shoveler ducks, which nest in islands in the Bering Sea and spend the winter in the Fanning and Hawaiian groups, a distance of some 2,200 miles. As the shore birds above enumerated are probably unable to rest on the surface of the water, the entire distance must be accomplished in a single flight. It is difficult indeed to see how this line of migration could have been established. Following the analogy of the Old World species before mentioned whose path marks an ancient shore-line, we might presume that there was at one time a land connection, or at least a chain of islands between the Aleutian and Hawaiian groups, but on the contrary the depths of the Pacific are profound between these points, and there is not the slightest geological evidence on which to base a former land connection. When it is recalled how slight a deviation at the point of departure would suffice to throw them to the one side or the other of the Hawaiian islands the accomplishment is truly marvelous. In the absence of familiar landmarks and surrounded by a waste of

sky and water, they make their way with the precision of a rifle bullet, and it would seem at hardly less speed.

The plovers, sandpipers and kindred species take migratory journeys often of extraordinary length. Thus the American golden plover (*Charadrius dominicus*) breeds in Arctic America and migrates through the entire length of North and South America to its winter home in Patagonia. The little sanderling just mentioned is almost cosmopolitan in distribution, breeding in Arctic and sub-Arctic regions and migrating in the New World to Chile and Patagonia, a distance of eight thousand miles, and in the Old World along all the shores of Europe, Asia and Africa. The Bartramian sandpiper (*Bartramia longicauda*) nests from eastern North America to Nova Scotia and Alaska, and goes south in winter to southern South America. The solitary sandpiper (*Totanus solitarius*) breeds mainly to the north of the United States and winters as far south as Brazil and Peru. The buff-breasted sandpiper (*Tryngites subruficollis*) rears its young in the Yukon district of Alaska and from the interior of British Columbia to the Arctic coast, and journeys in winter well into South America. The turnstone (*Arenaria interpres*), a little shore bird about the size of the song thrush of Europe, is also cosmopolitan, breeding in high northern latitudes and at other times of the year being found along the coast of Europe, Asia, Africa, North America, South America to the Straits of Magellan, Australia and the Atlantic and Pacific islands. It is one of the species mentioned as making the wonderful flight from islands in the Bering Sea to the Hawaiian Islands.

The ducks form another interesting group, although their journeys during the migrations are not nearly as extended as the birds just mentioned. The larger number breed mainly to the north of the United States and many within the Arctic Circle. Certain species, as the eider duck, only come south in winter to the coast of northern Maine, others, as the old squaw, may reach the Potomac and the Ohio, while most of them, as the bald-pate, blue-winged teal, pin-tail, golden-eye, bufflehead, etc., visit Mexico, Guatemala, northern South America or the West Indies.

Certain of the familiar birds of lawn, hedgerow and field, for whose coming we watch so anxiously, may claim a moment's attention. The bobolink, so dear to the hearts of the residents of New England, makes his appearance in his summer home in May. By the last of July or the first part of August the young are reared, the old males have lost their bright dress, and with a musical *chink* as their only note, they start southward. In the region of the Chesapeake they begin to congregate in vast flocks, where they are known as reed-birds, but in a few weeks they pass on to the rice fields of the South to become the dreaded rice-bird. But by October the last one has disappeared, and

some by way of Cuba, others by way of Central America, where a few may linger, the main body presses onward beyond the Amazon into central and southeastern Brazil. On the return journey they reach the southern border of the United States in March and April.

The catbird is found in summer throughout the eastern United States and British Provinces, and in winter in the southern States, Cuba and Middle America to Panama. Our common robin is very erratic in habits of migration. Occasionally a few may winter in dense swamps as far north as southern Canada and Maine, but the majority spend the winter in the Southern States. The chimney swift is found in summer in eastern North America and thence north to Labrador and the fur countries. The winter is spent to the south of the United States. Cliff and barn swallows, which are found over nearly all North America in summer, may penetrate to Brazil, Paraguay and the West Indies in winter. The scarlet tanager passes the winter in the West Indies, Central America and northern South America, and the familiar indigo bird may go as far as Veragua.

The great group of warblers, of which some 70 species are found in the United States, has been mentioned before. They are all strongly migratory and mainly pass beyond our southern borders in winter, although a few individuals of a single species—the yellow-rumped warbler—have been known to winter on Cape Cod. Some of them visit the West Indies but the larger number, after rearing their young in the dense coniferous forests of the Hudson's Bay region or even in Alaska, spend the winter in Mexico, Central America or northern South America.

The sparrows as a group are also strictly migratory. Quite a number, such as the tree sparrow (*Spizellla monticola*), snowflake (*Plectrophenax hyperboreus*) and longer spur (*Calcarius lapponicus*) breed far to the north of the United States in Arctic districts, and come down in winter into the northern states or irregularly farther south. Many species which breed mainly north of the United States only go into the middle and southern states during the winter, while a few may reach the West Indies, Mexico, Central America or northern South America.

But after having described these migration routes and the wonderful journeys over continents and vast oceans, the mystery of mysteries —How is it possible for the birds to find their way so unerringly?— still remains without a wholly satisfactory answer. As in the case of theories propounded to account for the origin of migration, so numerous suggestions have been made to explain this wonderful faculty. Thus Dr. Von Middendorff, a distinguished naturalist who studied exhaustively the migrations in the Russian Empire, suggests that because all the spring movements in that country are toward the

magnetic pole, the migrating bird knows the location of this point and is enabled to direct its course accordingly. It is perhaps needless to say that this theory is not only unsupported by any serious facts but, as has been shown by Baird, is opposed to the facts of migration in North America.

If during the migrations the older and stronger birds always led the way, it might be said with plausibility that this faculty is due in large measure to experience, but here again the facts are either conflicting or directly opposed to such a view, for it seems to have been demonstrated with reasonable certainty that in Europe the young birds not only precede the old, during the fall movement, but often travel by a wholly different route. In this country, however, observations on this point are limited and authorities differ, but the tendency is to believe that the old birds do actually lead. Observation is much needed to settle this question.

In the case of birds migrating over land areas, sight is supposed by some to have an all-important function, especially when it is recalled that a bird two miles above the earth is surrounded by a horizon line of 90 miles on either side. As already shown, they have been observed at a height of three miles, which would easily keep them within sight of prominent landmarks, and would even permit them to cross considerable bodies of water without entirely losing themselves. That they depend to some extent on such landmarks to guide them on their course seems to be shown by the fact that they migrate mainly on clear nights and are obliged to seek the earth on the approach of cloudiness and storms. But in the case of birds migrating over hundreds or even thousands of miles of open water, vision must play an unimportant part. Möbius ('Das Ausland,' Aug., 1882) suggests that in such cases they may be guided by observing the roll of the waves, but while this may be true in a few instances, it cannot possibly be so in the majority of cases. We, therefore, seem inevitably led to the conclusion that birds are possessed of a 'sense of direction.' This 'homing' faculty or power of orientation which is, for example, so strongly developed in the carrier pigeon, is by no means unique among birds. It is possessed in a greater or less degree by many animals, by most savage races of men and, not infrequently by individuals among civilized races, more especially those accustomed to life away from centers of civilization, in forest and on plain—just how it is to be explained is difficult to say. Some would give it the dignity of a sixth sense and would fix its seat in the semi-circular canals of the ear.

ENVIRONMENT IN RELATION TO SEX IN HUMAN CULTURE.

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THERE is a sense in which human environments may be viewed in their relation to sex.

The greater part of the earth's surface was sterile to all primitive peoples, anterior to the times when the harnessing of physical forces, little by little, brought all lands and all waters under human dominion. The seas, the mountains, the frozen regions and the deserts were never traversed by savage man. In other areas the soil was so rich that dense forests and impenetrable pampas, with their dreadful solitudes and venomous animals and plants, served as a prohibitory wall against human occupation until the good offices of fire subdued them.

The remaining areas, of which we are now speaking, may be divided into the bisexual, the feminal and the virile. These natural homes of humanity have been characterized as culture areas, areas of characterization, ethnic provinces, *oikoumenoi,* and so on, either by reason of their having produced marked varieties of the genus homo, or because special forms of activities have been demanded and fostered in them. Each of them has been studied respecting its salubrity, its food supply, its materials for elevating industries, its distance from the highways of progress, its scenery and resources of every kind affecting the welfare of our species; but here it is designed to interrogate them regarding their treatment of men and women.

The term 'progress' means the perfecting of mental attributes and bodily skill of the individual and enlarging the number of persons cooperating in the same activity over longer time and greater space simultaneously.

The exigencies of maternity always differentiated the activities, the artistic creations, the language, the social life, the knowledge and the religious conceptions of women. Over and above all actions in common with men, they were spinners, dyers, weavers, nest-builders and purveyors. For them the fireside was literally the focus of innumerable cares.

In any mode of primitive life, on the other hand, men went to war with the elements and with things. In their hands was the apparatus of capture, of incarceration, of slaughter. They exploited the boundaries of the unknown in every direction.

The three kingdoms of nature—animal, vegetal and mineral—were the arena upon which men and women acted the drama of progress.

The animal kingdom.

The animal kingdom was, on the whole, in relation to human progress, the lowest of the three, inasmuch as less exalting artificiality has grown out of it for women as well as men, but more exalting for men than for women. The ever-increasing wariness and remoteness of the animal called for increase of cunning, skill and united effort in man. The apparatus had to be more ingenious and effective, the individual hunter more resourceful, and men had to be mobilized in larger numbers, for longer times and for greater distances.

When the hunter state gradually passed into the pastoral state, the same pedagogy went on, for the hunter now came to be the aggressor and defender in the care of his flocks, killing rapacious beasts and men; and the annual hunt, a marvel of temporary concerted action and intelligence, coming to be the permanent military organization.

Face to face with the animal kingdom, the zootechnic activities of women were of quite another sort. It was they who skinned and packed the game, cured the fish and converted the soft parts of animals into products for human comfort. In the slow processes by which the feral states of animals became domestication, women collected the young, often nursed them, attracted the adult. In those areas where she could best do this was her vantage ground.

In the pastoral state the muscular energies of beasts became the servants of men, lifting many burdens also from the backs of women. Herein came the saddle beast, the pack beast, the traction beast, the permanent supply for art and for sacrifice. As to woman, it brought to her door milk, flesh and wool.

The vegetal kingdom.

In contact with the vegetal kingdom men were the inventors of woodcraft and bark-craft. Women were primitive gardeners, gleaners, basket- and mat-makers, and spinners. Edge tools, therefore, were man's—ax, adz, chisel, whittling knife, all for wood-working; but carrying-baskets and spindles were women's. Sedentary village life is the product of the vegetal kingdom. In its earliest form it is woman's sphere. To plant the seed, to till the ground and to gather the crop were hers. What men did all this time was to guard the women and the crops and to develop a military, regulative government. The mound region of the Mississippi Valley is an eminent example of this, where the remains of ancient corn rows survive in the midst of forts and ceremonial earthworks.

The mineral kingdom.

The mineral kingdom did most to emancipate the fancy and develop the genius and strength of men through stone and metal; for women, its pedagogic efforts were through the pliant and versatile clay and the water springs. Find a region south of the line of severe cold where clay abounds, coupled with demand for sedentary life, there the ceramic art in primitive times was efflorescent. The clay and the woman gradually become refined and exalted. The qualities of the material were discovered and developed, the great possibilities of manual refinement and dexterity found a worthy arena. In later times Keramos came to be a man, because machinery supplanted the hand; but at first potters were women.

On the other hand, if you except the scraper and the household knife, in flakable, siliceous stone, the worker in stone was always a man. Piercing and slashing weapons had their points and edges worked by men. It is with admiration that we now look upon the products of knack and patience kept in museums as precious relics of the men of old. Wherever the best flint was known there the men were quite equal to play upon the material and to be played upon by it, the flint and the artist being mutually perfected.

But friable stone had in it even more for man than flint. The gem cutter, the sculptor, and the architect went to school to crystals, to calcareous and volcanic stone. The flaker was invented for flint, but the hammer, the bushing tool, the chisel, the rasp, the diamond drill, the saw, the emery wheel and engineering appliances were all devised by men at the invitation of art and architectural stones. In those areas where these last abound men were regenerated. A casual glance at the map of the Western Hemisphere shows that only where the engineer and the architect were called for was there aboriginally any approach to civilization.

The forces of nature.

Professor Rouleau, of Berlin, divides culture into phases which he calls 'manganic' and 'naturistic'; the former term applies to the use of machinery and the domestication of nature's forces, the latter to that condition of culture in which the hand was aided by the simplest appliances. On every grade of culture women were more naturistic than men. Any culture area, therefore, which afforded occasion and stimulus for the employment of mechanical powers, the forces of nature, and continuous organized effort of mind and muscle was virile and most propitious for men.

Nor are conditions of climate and daylight to be neglected in this connection. For men, progress was more difficult in uncongenial climes. Women had sheltered, indoor temperature artificialized in the frozen zone with the help of the lamp-stove. Hence all the enduring monu-

ments of early man's advancement are only within those temperate areas or elevations where neither heat nor cold was excessive, and where the food-quest was not exhausting.

Interesting here also is it to note the length of day in culture areas, especially for out-of-door men. The following table gives nearly enough the duration of the longest and of the shortest day for the different latitudes:

70°	the sun is visible from May 16 to July 27.					
60°	longest	sunlight,	18h. 53′,	shortest	sunlight,	5h. 52′
50°	"	"	16h. 23′,	"	"	8h. 4′
40°	"	"	15h. 1′,	"	"	9h. 20′
30°	"	"	14h. 5′,	"	"	10h. 13′
20°	"	"	13h. 20′,	"	"	10h. 55′
10°	"	"	12h. 43′,	"	"	11h. 32′

Culture areas of the New World.

The Western Hemisphere offers the best field for studying culture areas and primitive life in relation to sex. The two extremities furnish a striking contrast between a sterile and a bi-sexual area. In Fuegia, with climate like that of Labrador, the conditions of living are such that beyond merely holding their own there is little to uplift either men or women.

On the contrary, along the arctic border are the cunning Eskimo, living in an environment that is both virile and feminal; but it is solely zootechnic. There the women are housekeepers, tanners, clothiers and embroiderers.

The men have the sinew-backed bow, the retrieving harpoon, and the skin kaiak, in each of which you see the maximum result of skill with the minimum of material. During the long winter the æsthetic faculty was exercised in carving and etching upon hard animal tissues. The underground ceremonial house and the snow dome are models of construction. Dogs were traction beasts, rapid transit over snow and ice was installed; harness, sleds of uniform width, economic food and packing sharpened the wits. The boundaries of the environment rich in animal life seemed unlimited, so that many hundreds of miles of shore country were exploited by a people speaking the same language. Inland, about the Yukon drainage, women were among the most forlorn pack beasts and slaves on earth.

The birch-bark area.

Eastward from the Rockies and throughout Alaska is the birch-tree country, quite poorly furnished for men, far better for men than women. The snow-shoe is at home here, and also the birch-bark canoe. Here

throve fur-bearing creatures in great variety, coveted by the titled and fashionable in the Eastern Hemisphere. The trader brought along with him the gun and the curved knife, with which men built better canoes and women cut the finest leather, called babiche. Result: better boats for water travel, better snow-shoes for snow travel and also better men and women. But primarily, after all, conditions were hard and starvation was not unknown.

The sleds of the birch-canoe region have no runners; they are boats to move on the snow. In the fur trade the dog became exalted through external stimulus, and the voyageurs were known as the hardiest of men.

In the realm of the æsthetic, however, through all the birch bark area men knocked at the door of Nature in vain. The fine art of both sexes was in ephemeral costume decorated with porcupine quills. No pottery, basketry, woodwork, stonework, earthwork or fine carving of any kind existed. Since the art faculty and the materials are always exalted mutually, it is in vain to enquire whether the one or the other was lacking.

The north Atlantic area.

The drainage of the St. Lawrence, the Appalachian mountains, and the Atlantic slope together formed the culture area for two powerful Indian families, the Iroquoian and the Algonquian. The annual round of varied employments, in peace and in war, developed a fine breed of men. Cultivation of maize by the women, added to their zootechnic activities, trained their wits in economy and cooperation. They were not excellent potters or weavers, however, and their advancement was far behind that of the men. Matriarchy was breaking down at the period of the Discovery. The early records of these two families abound in accounts of long journeys, of masterful enterprises, of concerted activities, of imposing councils, of treaties and alliances, which go to show that the Atlantic slope long ago could produce noble men.

The Mississippi valley area.

Between the Blue Ridge mountains and the Rockies, when the historian arrived, two contending cultures had been at work, evoked by the kingdoms of nature—that of the buffalo and that of the prairie. As the land of Egypt is the residuum of a continuous warfare between the desert dust and the Nile floods, so the phenomenon of roving tribes living on the sites of mounds and earthworks, of which they had neither knowledge nor tradition, was the outcome of the conflict between the hunting Dakotans and their congeners on the one side and the agricultural builders of mounds from the south.

The Muskhogean area.

If the reader will examine Merriam's temperature charts in relation to zoological distribution, he will note that the color symbol of the southern states of the Union extends far to the westward. He will not be surprised to find that the Rocky mountains lowered their drawbridges in times past for the migration of ideas. The Muskhogean tribes built pyramidal mounds. They were sedentary. The men were tall and mentally vigorous. Their descendants, now in the Indian Territory, were capable of great enterprises. The women were skilful farmers, weavers and potters. The gulf province was bi-sexual.

The south Atlantic area.

Southeastward from the Muskhogean area lie the Antilles, the Orinoco basin, the Amazon basin, the Mato Grosso and the Pampas. In them men had little to do save to hunt and fish, to fight and to sleep in their hammocks. They were zootechnic, passing into phytotechnic. No great man was ever bred in such a school. The women were farmers, potters, tapa-makers, spinners and hammock-knitters, and there is ground for believing that in several portions of the area there were settlements made up wholly of women, or Amazons (Payne, Hist. of Amer., II, p. 11).

The men in the northern portion were also water craftsmen, and that evoked and trained their hand, their skill and their wits. The Caribs are said to have been the only American people who colonized by sea voyages. In art, men were carvers in wood and stone, attaining creditable skill in Puerto Rico and Guadeloupe. However, as in other areas, there was absence of solidarity. The women on the Orinoco, the Amazon and the Xingu made exquisite basketry and featherwork, and jewelry of teeth and seeds. They cultivated cassava and other plants, and their cabins were thronged with birds of gay plumage. So lacking was industrial stone in all this lowland that shell and teeth were the only materials, on which account Von den Steinen humorously proposes to speak of a bone and shell age of man.

The tribes of the pampas, before the coming of the horse, had a meager life. It is true that the guanaco and the rhea were at hand plentifully. But the men in association with such environment were not much more than clever panthers with long and sharp teeth called arrows and spears.

The women were much more cultivated, being excellent tanners and making rude pottery. Their houses were only shelters of skin and their art was limited to painting geometric patterns on robes. The two sexes were equally non-progressive, but being amply fed they grew in stature and were among the tallest Americans.

The north Pacific area.

On the Pacific slope of America, between 45° and 60° north, lies a well-marked culture area. The mountains near by and the ocean have between them innumerable islands, great and small. Passing among these was easy; the climate, by reason of warm currents in the sea, mild; animal and vegetable life useful to human existence, copious. There is no flint, but slate, nephrite and volcanic rocks of good quality. On this domain men traversed long distances in dugout canoes holding fifty persons, and artists expressed their mythic fancies through the obliging cedar wood. Had they lived thirty degrees farther south, these men would have been able to rival the builders of Nahuan and Mayan stone temples. For women, pliant roots and tough grasses fascinated their artistic spirits, resulting in exquisite twined basketry. As in all other island areas, however, the tendencies are centrifugal. The linguistic families were separated into innumerable *kwans,* or clans, without national solidarity. The southern boundary of this canoe culture province is the Columbia river, highway of tribes and patron of men. On this coast were matured commerce, slavery, a diversity of industries and a varied annual round. Material was afforded and leisure also for the unfolding of a complicated mythology and its embodiment in wood, stone and hard animal substances.

The Oregon-California area.

The next unique area lies on the Pacific slope, between 35° and 48° north, chiefly in Oregon and California. Upon this long strip facing the sunset was woman's paradise; it was at the same time 'No man's land.' The men there are among the shortest, and the height of the women is 94 per cent. of the men's. Twenty-four different stock-languages are spoken. It is not so much a single culture area as a series of cul-de-sacs, a *cloaca-gentium,* coves in the mountains opening out on the islandless, harborless, fathomless ocean. It is the Caucasus of the Western Hemisphere. You see there no huge canoes, no carvings in any material, no partnerships or great enterprises. The only redeeming virile feature is the yew bow with sinew back and the most delicate arrows on the continent.

But what a heritage in textile materials! Nowhere else on the globe was there such a variety of stitches in basketry and nowhere else were women's fingers so nimble in basket-making. There was no spindle, no loom, no pottery, but the basket served all purposes for the gleaner, the miller, the cook and the purveyor. The art sense, almost extinguished in the men, barring a little skill in shell and feathers, effloresced in woman's work, to the astonishment of the ethnologist.

The Pueblo area.

The plateau bounded by the Colorado and the Rio Grande was long the home of the clay and adobe worker. The men were short, and the height of the women in the pueblos was 93 per cent. of that of the men. Rabbits, mountain sheep, antelopes, coyotes, mountain lions, hawks and rattlesnakes were the useful and mythical animals. The vegetal kingdom furnished poor timber, but good textile fibers and a varied diet of corn, melons and beans. As in the Ohio valley, though in different materials, artificial food production was associated with defense. The cliff home and the pueblo solved the problem of architecture and fortifications in the best possible situations and materials.

The artificializing of this pueblo life can not be divorced from water culture and cult, woman's prerogative. In a region whose life is a perpetual sigh for water, the nymph and the potter are one. Women are pack beasts for clay; modelers, decorators, burners of pottery. The water seeker, carrier, storer, user, server, is the potter. The tempting foods set before the gods of the elements were served in baskets and vessels of clay. The feminal life of the pueblos, therefore, was higher than the virile, and it is so to-day. Cushing says that the men's efforts were concentrated on activities connected with maintenance and the worship going therewith. Most of the fine art, however, excepting the little painted dolls, in the service of religion, is feminal; it is on pottery and basketry, not on shields and manly costume.

The Mexican area.

At the genial southern extremity of the same plateau, reaching from Quimbawa, in Zacatecas, to Nicaragua, lie the Mexican uplands, man's best friend in all aboriginal North America, as the region about Quito was in South America—a climate whose daylight varied little throughout the year, whose temperature was so equable that food plants, like the trees of the Apocalypse, bore their fruit every month, a region whose elevation and proximity to the gulf and the ocean gave the largest yield of land and sea food for the smallest effort, especially, however, a region abounding in architectural stone in which men might fix their epics and their dreams, and in hard rock for stone cutters' tools.

Mean temperature of the City of Mexico.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
75	80	80	79	75	69	69	66	63	66	70	73

Such a land was favorably situated for leisure, for organization, for unbroken cooperation in economic social and religious activities on a large scale and, proportionally, to develop the manliness of men. One

is not surprised, therefore, to find here in great profusion a summing up in stone, both in sculpture and architecture, of all the motives scattered in clay, wood, textile and feather-work over the northern continent. Here also are seen fully developed those virile art forms and decorations of which Cushing finds among the pueblos only vestiges on pottery and basketry. The high culture of the Mexican and the Mayan broke down in Honduras, Salvador and Nicaragua, where are even now found any number of unclassed, insignificant tribes.

The Colombian area.

The extension of the Cordilleras southward need not detain the reader. Stretching from Nicaragua to the southern limits of Colombia were the Muyscas or Chibchas, metallurgists and jewelers *par excellence.* It was in their country that Balboa heard of the great riches farther south. Theirs was the home of 'El hombre dorado,' or Eldorado, where, on the inauguration of a chief, a procession of men richly dressed marched to the borders of their sacred lake bearing him on a splendid litter. The chief's 'naked body had been anointed with resinous gums and covered with gold dust.' He was rowed to the middle of the lake and plunged himself in to wash the gold from his body as an offering, at the same time his followers casting in enormous quantities of gold and emeralds. (Bandelier, 1893, p. 14.)

The women were farmers, potters and weavers. They cultivated maize, beans, yucca and cotton. Irrigation was practiced, the ditches, no doubt, being the result of organized, far-reaching and long-continued labor among the men. The conditions for united effort in large architectural enterprises did not exist, but commerce in salt and gold was active. It was not until a widening of the area and a lengthening of roads farther south in the inter-Andean valley made larger aggregations of men feasible that the noblest of arts discloses itself again.

The Peruvian area.

The Quichuan, or Kechuan family, including the Aymaran, occupied a strip of upland two thousand miles long on the Pacific slope of South America, all parts of which were joined by trails. Here Indian men reached their zenith. The dissemination of their culture was conterminous with their speech. The foci of this virility were Quito and Cuzco. The architecture was rock-hewn and cyclopean, wrought with tools of stone. Agriculture had passed to the artificial conditions in which metallic tools were used, in which terraced gardening, irrigation, use of guano and grain storage were practiced. The llama and paca were bred in vast numbers for food, for textile material and for pack beasts. Metallurgists wrought skilfully in bronze, silver and gold.

Woman's work, some of which had passed on to the virile stage, was of the first rank in curiously-wrought pottery and in textiles made from paca wool, one of the finest staples, as their delicate spindle whorls will attest.

But these Peruvian uplands were the training grounds of men especially. Together the earth, the air, the waters, the tropical day, conspired to develop them. The sun was their chief deity, source of life and power, so their principal chiefs were its earthly viceregents. The barbarous and bloody rites of Mexico were absent, as were the graphic system and the pictorial literature. But the monuments of a departed glory remain.

Conclusion.

Did space permit, the Eastern Hemisphere might also be put upon the stand as to its treatment of men and women from area to area. It surely can not be an accident that, before artificialized transportation interrupted the ancient régime, centers of culture and refinement survived for millenniums. Pastoral regions, land-locked seas, rice fields, bamboo jungles, above all, granite and marble quarries, are even now surviving and drawing around them the same refined spirits as of old.

This recital would be without a moral if it did not also apply to the higher, manganic, complex environments in which civilized peoples are living. There are tendencies in some to degrade men, especially to take from them that spark of originality and self-reliance which is the source of virility, of progress, of family life, and to reduce them to intellectual and moral peonage. This, in ways not necessary to mention here, lowers the birth rate, doubles the death rate, degrades the survivors and destroys the state. From primitive times until now there never came any solid advancement to a people that had not something ennobling for men and women to crave, or that sacrificed them to any god or fetish whatsoever.

THE COLLEGE-MAN AS LEADER IN THE WORLD'S WORK.*

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IN the twentieth century the college-man is, more than ever before, the leader of the world. Mind leads the world; mind ultimately is the ruler of the world. That mind leads the world which is not simply developed into maximum intellectual perfection; it is that mind which, perfected and strengthened and given symmetry and vigor, is also made most thoroughly at one with the world. It is not enough that the man shall be a great scholar, or the greatest of scholars; nor is it enough that he shall represent the highest culture and possess the most vigorous brain; nor can learning, even learning united with wisdom and culture, however magnificent the whole, in union give leadership in this world.

A primary requisite of leadership is close and strong connection with the great world to be led. This union being assured the true leader gains and holds his leadership by the exercise, in unrivaled power and with unequaled tact and judgment, of those talents which have been reinforced by the no less indispensable learning and culture and wisdom; these united confer leadership. Ultimately, also, it must be remembered that the greatest mind can never lead if apart from the world and out of touch with those who are to be led. Any man of good sense and rich in humanity, even though unlearned and without extraordinary genius, will sooner acquire leadership than the wisest and greatest man of genius the world at the time possesses, lacking this firm hold upon those who should follow.

He who would lead must have this compound constitution and must acquire the useful forms of learning and the hardly less valuable forms of culture, for such purposes, and he must cultivate that wisdom and tact and those virile qualities which are all-essential to perfect success. He who would lead must be prepared closely to follow leaders preceding him, and the requisites for following leaders in the front ranks are substantially the same, apart from the peculiar genius of the general of the army, as for leadership itself. And each should be well prepared to follow, each in his proper place, and there to be content while most efficient.

The twentieth century man will unite the qualities of sage and

* A Commencement Address, Case School of Applied Science.

worker and organizer and administrator as has no man before him. Uniting better than in earlier centuries the essentials of the perfect man, he is to do a larger and nobler share of that upbuilding of the nation which shall come with the realization of the prayer of the great American poet:*

> "Our fathers' God! From out whose hand
> The centuries fall like grains of sand.
>
> . . . . . .
>
> O! Make thou us, through centuries long,
> In peace secure, in justice strong!
> Around our gift of freedom draw
> The safeguards of our righteous law;
> And, cast in some diviner mould,
> Let the new cycle shame the old!"

A century ago there was but one recognized form and method of education—what is now termed the classical—composed of studies of the ancient languages and literatures, comparatively lean and narrow as they are; the elementary mathematics, to the extent now attained in the secondary schools; a homeopathic dose of physics and chemistry; a little French; and a somewhat larger, if less palatable dose, of 'philosophy.' The century has been one of extension, broadening, elevation, diversification and systematization of education, and of the incorporation into the curriculum of the modern languages and literatures; the modern physical sciences experimentally developed; the arts, fine and useful, so far as capable of scientific treatment; and the principles and practice of the professional schools, including the latest and most strictly taught of the group, the school of engineering and its associate professional schools of every sort. The whole evolution of the century has been consistent in every field and technical, 'practical,' education is simply one of the elements of a complete and perfect evolution of modern life.

The world now acknowledges its need of the college-man and my own letter files are crowded with calls for competent men far in excess of the number available; while the number seeking even improved situations is small, and I know of none out of work, unless ill. At the top, the space is enlarging, though it is always ample for tip-top men. Formerly positions paying five thousand dollars were rare, now the college-bred man is coming forward when ten-thousand-dollar positions are seeking, and failing to find, the men who are competent to fill them satisfactorily. Generals are, comparatively, still more rare than ever, even though training for generalship is going on at an unprecedented rate and the opportunities are multiplying for great men and good men and capable men as never before.

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* Whittier.

And among the leaders of the world, nobly rivaling every other, stands the 'Captain of Industry,' now rapidly developing into general and field marshal. Note what this sort of man has done for the world!

The inventive mechanic and the engineer, learned or unlearned, have, in the course of the nineteenth century, given to the world the locomotive and our whole system of general continental and transcontinental transportation, the steamship and all our contemporary ocean and river, freight and passenger lines, the automobile and the beginnings of a new and still more widely helpful system of common highway transportation. They have given us the mowing and reaping machines which have reduced the time and cost of harvesting to a tenth and less of its former value; the seeding and the threshing machines which have done as much in their special fields; the sewing and the knitting machines which have given the sewing woman and the housewife multiplied working power with minimized exertion and reduced working hours. They have provided the power-printing press with its almost miraculous speed and accuracy of printing, counting, folding and binding together the sheets of a metropolitan newspaper 100,000 an hour; the type-setting machine and the linotype, making easy and productive in hardly less degree the labor of the type-setter; the whole machinery of modern textile manufacturers with its multiplied efficiency and the iron and steel industry, the fundamental element of civilization.

The electrician and the mechanical engineer have provided us with the electric current in useful and infinitely pliable form, transmitting energy of all mechanical prime motors from the source, or point of surrender of energy by nature, to the point of application, a mile, ten miles or a hundred miles away, with little loss and with vast convenience and economy. The engineer is even furnishing power for use in transmitting messages over the telegraph wire. In our homes, steam-heat, ventilation and sanitary life come largely of the inventions, the constructions and the operative mechanism of the engineer, who provides the steam-boiler, the water supply, the forced ventilation, all unknown to our fathers, luxuries to many still, but which will become the ordinary and commonplace comforts of the great mass of the people in the coming century.

The mechanic and the engineer have provided us with iron ships and naval armaments, the battle-ship and the torpedo-boat, the 'submarine,' and guns that have a range of ten to twenty miles. They are thus doing practically all that is actually being done, at the time—they have done practically all that has been done during the century—toward making an end of war by making weapons too effective to permit their use by nations except in desperation and under extreme provocation. Under such provocation, in the future as in the past, nations will probably make war; but it is the engineer, probably, who will

always prove the effective peacemaker, both by his tremendous power of making war costly of life and property and, especially, by his no less tremendous and vastly more admirable power of making the arts of peace the means of attaining a higher civilization, of advancing the interests of the people, of uniting all peoples in common interests and making political boundaries subordinate to the best interests of all.

Thus has the inventor and the mechanic provided the apparatus of production of a new world and converted by its use barbarism into civilization, light into darkness, developing in slave and drudge soul and intellect and humanity. But it is not enough that the apparatus should be provided; it must be placed in hands competent to use it effectively and the whole modern organization of industries constitutes the no less essential apparatus of utilization. Its armies of workers must be directed by officers of every grade, commissioned and non-commissioned, generals, colonels, majors, captains and lieutenants, sergeants and corporals. Without organization the armies of industry degenerate into mobs and threaten life and property and become entirely incompetent to keep in motion the machinery of production. Well organized, every invention finds its use and every people profits by its employment; production proceeds with increasing efficiency and the world grows comfortable and happiness becomes attainable.

Says Carlyle: "The Captains of Industry—happily the class who above all, or, at least, first of all, are wanted in this time. . . . It may truly be said, the Organisation of Labour (not organized by the mad methods tried hitherto) is the universal vital Problem of the World. . . . The few wise will have, by one method or another, to take command of the innumerable foolish; that they must all be got to take it; and that, in fact, since Wisdom, which means also Valour and heroic Nobleness, is alone strong in this world and one wise man is stronger than all men unwise, they can be got. . . . This I do clearly believe to be the backbone of all Future Society, as it has been of all Past; and that, without it, there is no Society possible in the world."

These are the sentiments of that powerful, rough, mainly accurate philosopher, as expressed in his 'Latter-Day Pamphlets,' about the middle of the nineteenth century. Carlyle, judging the works of men, would, I am sure, declare that the noblest work of all, in our time or in times to come, shall be adjudged that of the captain of industry, who, in his long life of struggle and of strife, leading armies of men to victories over material things and against obstacles set by ignorance, prejudice, opposing interests and envy and malice, finds employment for thousands, gives the people some essential of the people's life at continually reducing costs with continually rising wages, gathers his millions while giving to the nation hundreds of millions, and then, his struggles and strifes at an end, gives his remaining years to distribution of his wealth in the founding of libraries and to the support of the

higher education that he himself may lack. Greater than generals leading armies in battle, nobler than the founder of a family based upon wealth, grander than peer or even less self-abnegating royalty, his example is more inspiring than that of any so-called successful man, in any vocation, in any profession, in any station in life, *if* the exemplar lacks this splendid impulse to production of higher results in expenditure of wealth than in its accumulation. Name and fame and dignity and station all find eclipse in the greater name and fame and dignity and station of him who thus practically illustrates the workings of the soul of Abou ben Adhem. At the last, indeed, that man shall have all these and more; he shall add to them all that better reward, conviction of having earned the approval of conscience and of all good men, of all honest citizens and every patriot, of all men whose esteem is worth having in this world, and the pronouncement in the next: 'Well done, thou good and faithful servant!'

And what more splendid example, eliciting the finest ambitions of the young men coming after him, can there be than that of a man conquering success by overcoming every obstacle that fate can place in the way of the earnest man, gaining all the rewards of this world, and then —giving all back to the world in ways promoting its highest welfare!

I doubt if there can be one; yet I think I can see a modest rival. Not all men can become generals, colonels, captains in the army of industry; but a small fraction can even secure the sergeantcies. Many a man, starting out with high hopes and splendid promise, confident, brave and efficient, loses his hold upon the essentials of success and must settle back into a life comparatively unfruitful, if not absolutely unsuccessful as judged by our usual standard. Yet such a man may be the grander character, the greater hero. His world may be restricted to his little sphere of minor duty or even to his home; but even there opportunities will come to him, and his character may ripen, his influence broaden, his work ennoble him and all those about him. It is the spirit of the man that makes success and makes all opportunities fruitful, whether leading an army or serving as private in the world of finance, of business of whatever sort, or within the walls of a humble home.

The spirit of the *Man with the Muck-rake,* happily, is not that which inspires the young man of to-day. He is too intelligent and his thoughts rise to too high a level to be misled by the impulses of the miser; for he who pursues wealth alone, and for itself alone, is simply a miser. However brilliant and however fortunate and whatever the altitude of his position in the world of business, struggling simply for fortune and mere wealth for its own sake means a mean and miserly life. He is the man with the muck-rake. However large his pile of glittering dirt, it rises simply as a memorial to his folly and his vulgar

aspirations; it has no more value, unused for noble purposes, than any other mineral, than the most common and the dirtiest of dirt.

Struggling for wealth for a great purpose glorifies the otherwise inglorious contest with all the lowest elements of greed and selfish ambitions and meanness in all its protean forms. Williamson, living a life of almost miserly frugality, seeking and saving and piling up wealth from early manhood to old age, living and dying in apparent penury that he might do a great work at the end, becomes a noble figure when seen by the reflected light of his philanthropy and the fine closing act of that long, inglorious life. The founding of the Williamson School for orphan boys where they can find homes and careful training and apprenticeship to useful trades, and later work with selected masters and employers, is a deed which renders immortal the man whose life seemed so unheroic. That act built for him a memorial that shall last as long as human respect and admiration for heroic deeds and love for self-sacrifice, self-immolation in a good cause, shall endure. He gave opportunity to humble and poverty-laden youth aspiring to educate themselves for their work.

Already we are seeing evidence of the change that is coming and of the value of careful training of the gymnastic and the educational improvement of the man through systematic and scientific instruction and drill. The leaders of even the world of business are educated men, as a rule. Morgan, the leader of finance to-day, is a college-man, a graduate of Göttingen; none of this class of men is likely to advocate the endeavor of a people to become a crowd of wealthy boors rather than a nation of gentlemen, scholars and wise men. The great financiers of the country are now usually college-men; the heads of railways are often of that class, even though they have begun at the foot of the ladder; all distinctively learned men are of that class; our greatest men in literature, science and art are practically all educated and cultivated men; the inventors of the telegraph and the telephone were both educated and, in fact, learned men; all the great men in medicine and surgery are college-men; all the great lawyers and every great jurist on the bench is of the same rating. We make our presidents of learned men and usually of college-men; the same is true of the members of their cabinets, of the judges on the Supreme Court bench, of the chiefs of bureau, and practically all men in highly responsible positions. Our foreign ministers and ambassadors where reflecting special credit upon their country, like Lowell and White and Hay and Choate, have been not only college-men but distinguished for their attainments in the highest fields of academic learning.

In engineering no man will in the coming generation have even an average chance of success professionally, without uniting to the essentials characteristic of a 'general of industry' in generations

just past the now hardly less essential requisites furnished him by systematic instruction in the sciences underlying his art and the applied sciences and the scientific methods fundamental to his profession. Now and then a man may get on and even possibly attain a high or leading rank; but it will be at enormous sacrifice of strength, energy and physical vigor; and when he reaches his goal, it will prove that he has gathered 'apples of Sodom' for a 'Barmecide Feast' and he will mourn, as have so many before him, the lack of that which makes a life of independence and of liberty in expenditure worth having. He will probably, as have so many before him, if his long life of self-seeking has not poisoned his character and killed all his sympathies, seek the next best thing and try to help other later youth of ambition and energy secure what he so greatly needs.

While it is largely true, as has been asserted by more than one such man, like the fox in the fable seeking to justify his amputated tail, that the prizes of our time and our country are now being often grasped by the uncultivated and unlearned man, the fact is mainly due to the circumstances that these men of to-day are mainly uneducated through the misfortune that they were born too soon and before higher education had come to be general and suitable to the conditions of modern life. In another generation this situation will be modified in the direction of giving these opportunities to educated men in vastly larger proportion. Meantime, every successful man, lacking education, learning and culture, recognizes to-day, either that he has also lacked wisdom if deliberately declining to secure an education when young, or that he has been extremely unfortunate if deprived of that privilege by force of circumstances. Not a man of them but envies his poorest acquaintance who possesses the essentials of content in a life outside the narrowing and engrossing pursuits of a business life. He lacks preparation for precisely what all his energies have been directed toward—making suitable provisions for a profitable and happy life on a higher plane.

Visiting the famous Homestead steel works, some years ago, the gentleman who was taking me through the mills pointed out a strong, good-looking and evidently masterful man standing on the top of a set of heavy roll-housings in the armor-plate mills and remarked, 'That man is paid more than your college president' and, indicating another who was directing work not far away and who evidently belonged to the same class, the most intelligent of mechanics, he said: 'That man is getting pay exceeding that of any one of your professors.' Both men were soiled and grimy, dressed in overalls and, as occasion arose, ready to take a hand in the work, and to the unaccustomed eye of the casual visitor they would seem to be day-workman; but one familiar with such scenes would instantly detect the bearing and manner of the born gen-

eral, prepared through natural force of character to command. They were men from the ranks, active, ambitious, good workmen, strong, proud, yet pleasant in their intercourse with all about them, and perfectly well prepared for their places by knowledge, experience and natural fitness.

Why were these skilled mechanics paid the salaries of college presidents and of college professors? The answer is simple: They could make themselves so useful and so necessary in the business that the proprietors could make money by employing them, large as was their compensation. Precisely the same principle operates when the presidents of great corporations receive tens of thousands of dollars as salary, or fifty thousand or a hundred thousand. The directors of such enterprises do not give away a hundred thousand dollars simply out of kindness; their enormous interests compel them to seek out the one fittest man in all the country, the man who is sought by perhaps many other great enterprises as a guide and director, to make those interests safe; identifying him, him they must have at his own price. Similarly, the great leaders in the industries take a few millions of the many which they earn for the people; it is quite fair.

The unlearned and uneducated man will always have his place in this world of ours; but yet he will not hereafter have such opportunities, however great his natural abilities, as he has had in the past. It is sometimes—not very often—said by 'successful' men of this class that the boy who grows up without learning, and who gives his boyhood's years to unskilled labor in shops and factories and mills, may hope for a larger success than he who is taught sound learning or given a 'liberal and practical' education. They speak without foresight or forethought. The world of the coming generations is to be a very different world from that of these last, even as the last generation lived in a very different world from that of their fathers. Education is permeating the whole body politic and rapidly becoming distributed to all ranks in life. For one poor man's son in college a generation ago there are many to-day, and for one hundred years ago there are now the many multiplied, and the man who would succeed, in whatever rank of business life, in whatever profession, must hereafter meet in competition men who, in addition to all the native talent which he possesses, and all the energy, vigor and ambition which he may display, will have a brain stored with knowledge and scientifically cultivated and trained, and thus far better equipped than formerly for successful struggles with the world and for seizing the opportunities and meeting the responsibilities of the highest positions for which all may strive.

This is, in fact, admitted, and it is often asserted by the most wise and able and successful of this very class, and Andrew Carnegie is

founding libraries, is promoting technical education and is organizing a great technical institution as the noblest contribution of which he can conceive for the benefit of those working men to whom he owes so much and indebtedness to whom he so freely acknowledges. His great pupil, Mr. Schwab, while encouraging the penniless boy to begin bravely at the bottom and to work hopefully toward the top, still more emphatically declares his respect for learning, and his high estimate of the desirability of more general education, by himself organizing a trade-school for Pittsburgh. A very large part of the work of founding schools and colleges and universities and every form of higher, as well as primary, education, outside the common-school system of the United States, has been already done, and is being performed more and more generally and liberally and generously by this very class of men. Rockefeller builds up Chicago University; Ezra Cornell, uneducated and once in poverty, nevertheless gives all his surplus, once secured, to found a university in which 'any man may find instruction in any study' and interests himself most of all in providing for the poor man's son; Hiram Sibley, owing his millions to the same sturdy, manly and vigorous spirit, fighting his way from the bottom to the top, finds his noblest pleasure in organizing a college in which the education of the young mechanic and engineer may be carried up into the realms of applied science and the highest departments of professional work.

Lawrence and Sheffield, Case and Rose and Rensselaer, and the numerous other great philanthropists who have founded schools and colleges, even the most thoroughly educated and most cultured of all amongst them, it must be remembered, had no such educational opportunities as are offered the young men and women of to-day. The coming generation is to be comparatively highly educated people, and the man who is to succeed in dealing with the new, the modern, man must, more than ever before, have something of that culture. Highest success will only come of education and culture combined with a thorough scientific, professional preparation for the most advanced positions in the industrial or professional organization. In the past generations few men were given, or could be given, even the academic education of the time; to-day, almost any man who has the wish and a real determination to succeed may secure a good education of the kind which he may most desire. In the last generation the competition for the high places and grand prizes, outside the then so-called learned professions, occurred between uneducated men, as a rule; in the generations now coming forward that competition will be between men who have not only the brain and the native talent, but also, and superadded to all that the older type of man possessed, that kind of systematic training which makes the intellectual as well as the physical gymnast, that scientific instruction which provides learning that finds its peculiar

use in the industrial departments of life, out of which come, directly or indirectly, all great fortunes.

This is already coming into view as the characteristic change of the time in the making of the personality of the notable man of the time. To-day the educated men are taking their place in the world and their chances of success are, and have long been, vastly greater, in most directions, than those of the uneducated. The proportion of educated men taking their places in history is already fifty times as great as of the uneducated; the next generation will see practically all great prizes in their hands. It is a splendid evidence of the progress of the world that he who chooses may enter the ranks of the educated, and he who will may make himself a man of culture.

As for opportunity to gain the prizes of common life, 'what more can the college-man ask than he now receives?' One man in a hundred to-day obtains a college diploma; these men supply one third the Members of Congress, one half and more of our presidents and vice-presidents, two thirds of our Supreme Court justices, seven eights of the chief justices. In all ranks, in all great places, the names of immortals are in the proportion of fifty to one, favoring the college-man. If, as asserted by some writers of late, as I however think mistakenly, the proportion of college men to population is falling off, then so much the greater will be the opportunities of the wise. If, as presumably is the fact, college-men are more and more pursuing professional studies, that means the elevation of the professions to a higher level and still larger opportunities for the college-man fitted to lead. To-day, the college-man has thirty times as large an opportunity to succeed in public life as the non-graduate, fifty times as large an opportunity to reach the cabinet, the vice-presidency or the president's chair, sixty or seventy times as large a probability of success in striving for the Supreme Court, eighty or ninety times as favorable chances of becoming Chief Justice.

In the great industries there are probably a still larger proportion of positions which, without the scientific learning and systematic training in applied sciences given by the engineering schools, the most ambitious of men and the most talented could not attain or attaining, could not hold. The coming century will see these opportunities more and more the prize of intellect suitably trained, of mind properly strengthened, of talent precisely outfitted for the task of their acquirement. The college-man will come more and more generally to take and to hold one hundred per cent. of the positions assigned the generals in the great army of industry. This is the more probable since, as is asserted by a foreign and unprejudiced observer, 'The engineering profession is to-day, upon the whole, the best educated in America.'

In all the later centuries until the nineteenth, the college-man

seeking to unite with learning and culture, with knowledge and wisdom of the sorts approved by the older academicians, that no less noble and still more helpful learning of the sciences and of the arts of industry, joining the academic with the scientific and the professional, has been at a disadvantage among other college-men. The end of this discrimination among learnings is now in sight, and one of the most striking signs of the times in this direction is the recent action of the Emperor of Germany and his government, and of the Emperor of Austria-Hungary and his officials in ranking the scientific and the professional schools beside the universities.

Many years ago, at the instance of your annalist, was initiated the degree of Doctor in Engineering; later, it has come to be the fact that at least one university has established entire equality between its colleges of arts and sciences, those of applied science and engineering and its professional schools, both in requirements for entrance and in those for graduation, as well as in value of its degrees in those departments of learning. Only recently, the Emperor of Germany has announced the same democracy of learning for his country and the Emperor of Austria-Hungary has followed suit, making the doctorates of engineering and of the applied sciences, and the institutions permitted to confer them, co-equal with the doctorates of philosophy and their conferring universities.

I have wondered whether the presence of our distinguished scholar and teacher, Ex-President White, at the court of Germany has not had some influence in this progress; but, however that may be, the American democracy of learning is now accepted in Europe and the complete emancipation of the universities from the old monastic influence will not be long deferred. The making of the head of the great German 'Polytechnicum' a '*Rector Magnificus*' has a great and a most encouraging significance for all nations.

The college-man is he, who, in the days which are now come, when practically every one who wills can secure learning if not wisdom, knowledge if not culture, sees opening before him the largest and most attractive opportunities. Whatever any other man may possess, he has that which permits him to aspire to companionship with, if not leadership of, the greatest and noblest in the land and of the time. Given similar physical vigor, equally strong aspirations, similarly clear and strong intellect, no less refined sense of justice, sympathy and manly brotherhood with men, it is the college-man alone who has the advantage of systematic training of faculties, of most efficient teaching, of scientific knowledge and of highest learning through communion with the greatest men and the loftiest minds of the present and of the past, and who may with greatest confidence undertake the leadership of men. It is the college-man who is best equipped for generalship

in the industrial army, for farthest exploration of unknown fields of science, and for loftiest rise in the philosophical world and, even with similar elementary experience and training, for greatest success in the lower, but none the less great, world of money-makers. The twentieth century man will be the college-man, in type, and it will be college-men, as a rule, who may be expected to go farthest and rise highest and to do the great deeds of the coming centuries, whether in finance, in the industries, in political life or in the highest realms of science and the loftiest worlds of morals and philanthropy.

Shame be to him if, with all his advantages, he permits another to wrest from him that leadership by greater desert, by more perfect fitness. Glory be to him if he do his duty and splendidly, as he may, accomplish his grand task!

The college-man is evidently ere long to take charge of our public offices and of the industries and professional departments, and college-men are to find their way into prominent positions as never before; but, fortunately, college-men come from all sorts and conditions of people, and it can never be said that this means the organization of a class to dominate other classes, much less the masses. The sons of poor men, as a rule, always have been, and probably always will be, able to secure these positions oftener than the sons of rich men; for they have the discipline in early life that the latter usually lack. The process of promotion of the college-man is to be one, as well, of constant redistribution of power among all classes, very much as common experience shows the wealth of the country to be as constantly in process of redistribution. The democracy of intellect and the democracy of influence will be insured by this process in the most desirable of all possible ways. The way is now opening to the college-man as never before, and especially the departments of applied science and the industries offer him opportunities beside which those of the college-man in the other professions are insignificant.

In another generation the proportion of men, educated and uneducated, who attain success will be vastly changed, and, happily, the number of men who have reached competence or wealth in their vocations and who must still sigh that they cannot give of their millions to gain the education which they lack will be, probably, comparatively small—for the ambitious poor boy will much more commonly than now find his way to his triumph by way of the college or the professional school. The number of wealthy men who will esteem it a privilege to help on the work of education and to take part in other great works will undoubtedly also steadily increase until, as we may perhaps hope, the redistribution of surplus wealth may become the pleasure and the recognized duty of all.

The college-man, leaving college, goes out into life, once more a

freshman and with the university of life for his next place of struggle, of aspiration and of achievement. He enters upon a new training by different methods and through radically different experiences. He is trained indeed but by no sympathetic and systematic teachers. He must find his own way to knowledge, and to wisdom which is greater than knowledge, and must struggle onward and upward with not only little assistance, but even with almost every man's hand against him and driven, at times, to raise his hand against every man except the select few whose interests or whose convictions coincide with his own and are opposed by all the world beside. But this is not difficult for the man who knows himself in the right. In all men, it is obvious to the close observer, there exists a fighting instinct which has its use in life and the joy of contest makes easier the struggle for the intended goal.

Honesty, ability, capacity and power, supplemented by precisely the right sort of learning and made available through systematic training, in every case prove winning quantities. The complete development of the man to a maximum of usefulness in the vocation and the life to which he is by nature best fitted, means progress and ultimate success —*provided* he can keep himself in training. An essential element of the art of success is that of living long enough and in a state of high working efficiency. The fact that this is so generally ignored makes the opportunity of the man who never forgets it all the larger.

It is also the fact that it must be admitted that the incapacity, the lack of integrity, the indifference to duty and the general inefficiency of the average man is one of the elements of the success of the man who does finally succeed. But, sad as is the fact, it may fairly be accepted by the man who is at once gentleman and scholar and expert, as contributing to his opportunity.

And now, at this period of blossoms and nature's most beautiful season of promise and of hope, our young men and our young women are going out from the colleges to meet their opportunities. In these early days of the twentieth century, the college-man is the man of the century as never before, and the college-woman is, as never before, his most efficient helpmeet. All paths open to them and all fields are theirs for cultivation and 'all sorts and conditions of men' look to them for leadership and guidance. Theirs it is to prepare for leadership of every industrial army, for conquest of every unknown kingdom in nature's as yet unexplored realms, for discovery of uncounted secrets of the mysterious workings of physical law, of sources of energy and of new methods of utilizing all forces and all substances. These are they who shall become generals in the industrial armies, expounders of law, presidents, capitalists, benefactors of humanity.

For every one, if he will but seek it, there lies ahead a career as full of accomplishment, of honor, of usefulness to the world as his best

aspirations can reach, if he will but use his talents, his physical powers and his moral sense to the full extent of his capacity. His it is to lead in invention, in every art, in manufactures, in commerce, in philosophy, in morals, in accomplishment of the destiny of the century. Not all will lead, but all may follow where they cannot lead, and every one may do a good best and reap a reward proportional to the earnestness, the energy, the ambition and the discretion which he may display in usefully employing the learning and wisdom and the *savoir faire* which he may have acquired. Not all may become generals, but each may become colonel, major, captain or lieutenant, as his capacity and ability may give opportunity; each will gain quite enough to give satisfaction and ultimate profit. Patience and contentment were the ideals of the earlier times; but to-day the word is ambition and determination to make the most and the best of opportunity; content and patience are now means to an end and the end is accomplishment. To be content with what is gained but ambitious to secure new prizes, to be patient in struggling against obstacles while none the less determined to overcome them, are principles of life for twentieth century men and women.

Success in business and in professional life is simply the means to an end and that end is the power of helping forward the brotherhood of man. A competence is sought by each and all; but it is competence to secure, when the struggle is past, opportunity for greater deeds in the promotion of all good works, as well as in the enjoyment of all the wonderful things that the century shall offer to the cultured, the learned, the wise man. Wealth has its attractions for all honest men; but it is desired by the wise man only that he may emulate the great men who have already shown what good may be accomplished by its powerful enginery.

The twentieth century man is the college-man; and the college-man who is hereafter to lead and who will be remembered as a leader is he who uses his splendid equipment for the advantage of his fellows.

The 'self-made man' commands honor and compels our admiration; but the self-made man is usually a very incomplete piece of work and his kind will less and less hereafter succeed in competition among more perfect men in the life of the coming days. Only the man who has had a systematic education and training can hope to successfully compete with the world's leaders, educated, able, learned and strong as they must be, and possessing, as they must, also, quite as much natural power and constitutional vigor as he. The twentieth century man, the college-bred man, doing his best will do a better best than can the other man without the now essential knowledge and culture.

THEOLOGY VERSUS THRIFT IN THE BLACK BELT.

By CHARLES BARTLETT DYKE,
HONOLULU.

THE negro's real menace to the South lies in the paucity of his earthly wants. His few demands upon the world can be met with little exertion, and the outgrowth of his indolence is vice and crime. Generations of slavery have crushed out the spirit of accumulation. The 'collecting instinct' so prominent in the early life of the white child, is almost lacking in the average negro child of the South. Poverty, even though it may entail dishonesty, is too often accepted as a dispensation of Providence, to be compensated for later by the glories of Heaven.

A recent study of twelve hundred negro children brings out strongly their limited ideas of what constitutes wealth, their lack of thrift, and the sanction placed upon poverty by their religious teachers.* These children returned written answers to the following questions:

Would you like to be rich? Why? How much money of your own did you have last week? What did you do with it?

One half of the replies came from the cities of Wilmington (Del.), Baltimore, Washington, Norfolk, Newport News and Hampton. The other half came from the most enlightened rural districts of Virginia, Georgia, North Carolina and Alabama.

To all these children, from city and country alike, wealth means only the satisfaction of the simplest and most legitimate wants. To wear shoes and an overcoat when it is cold, and to have a hot fire in the winter, to have enough money to pay the landlord and the grocer, to own a horse or a cow or a mule, to assist the mother, so that she will not have to go out washing every day—this is their idea of riches. A boy of twelve wants wealth "So I could be more comfortable and have a better home than I have at this time. If I was the writ kind of a man I would spen it for food or wood or coal for to burn."

Girls of thirteen write, as reasons for wanting to be rich: "When you want anything you get it, and you don't hafter sit down and wish for it because you don't get it when you wish." "Poor people cannot have anything they want because they have to pay store bills, and the landlord is running to the house every Saturday night for rent."

* The writer wishes to thank for valuable material Miss Kruse, of Wilmington, Del.; Miss Grooms, of Baltimore; Mr. Cardoza, of Washington, and the members of Mrs. Dyke's Hampton Child Study Circle.

Several children wish for wealth 'because so many white people are rich' and a boy of thirteen explains, 'If I were rich the white man would not cry my name down but would be my friend.'

It is a regrettable fact that one fifth of the children who desire wealth, expect to 'live bedout working,' as a nine year old boy puts it. Aladdin's lamp is sadly missing from the lives of these twelve hundred children. Their most extravagant desires are as limited in scope as the children voicing them are limited in number. Ten children would travel if wealthy, seven would run a store, two would be conductors on street-cars, five would own pianos, four bicycles, one a 'five-dollar doll' and one a horseless carriage.

But pathetically limited as is their idea of wealth and the wants which it would supply, half of the older children from the rural districts reply with a decided negative to the question 'Would you like to be rich?' Their religion has forced them to choose between comfort in this world and bliss in the next. A girl of sixteen expresses the prevailing sentiment in her answer. "No, I would not like to be rich. Because the Bible say it is just as impossible for a rich man to get to heaven as it is for a camel to get through a cambrac needle eye." *

As is shown by the following table, the hostility toward riches is an increasing factor in the lives of both city and country children.

THE ATTITUDE OF NEGRO CHILDREN TOWARD WEALTH.

Ages.	6 to 10.		11 to 13.		14 to 20.		All ages.	
	City.	Country.	City.	Country.	City.	Country.	City.	Country.
Percentage desiring wealth.	93	82	90	70	83	50	91	65
Percentage desiring poverty.	7	18	10	30	17	50	9	35

While fewer than one fifth of the older children living in cities repudiate wealth, one half of the country children from fourteen to twenty years of age distinctly declare their preference for poverty.

The children of the city poor usually see the ordinary comforts of life in evidence among their more fortunate neighbors and often their ambition is aroused to acquire equally desirable property. On the other hand, in the rural districts the standard of living varies less widely, and there is less evidence of prosperity to stimulate the desire for wealth. However, the disproportionate number of country children who exalt poverty does not depend upon the merely passive effect of neighborhood conditions. Their papers bear proof of positive teaching that the accumulation of property is opposed to religion. Almost all who repudiate wealth do so on religious grounds. Between the

* The common 'reading' of Mark 10, 25, by illiterate preachers.

civitas diaboli of the wealthy and the *civitas Dei* of the poor a sharp distinction is drawn. The wealthy are declared to be sickly, discontented and unhappy, spending their nights sleeplessly guarding their treasure. They are wicked and cruel, and 'get their wealth by stealing from the poor.' A girl of sixteen sums up the general impression in her statement that 'A rich person never feels happy, they is always sad and unhappy.' 'Them that is not rich is happy Always.' The attitude of the great majority is that 'God don't leck rich folks.'

The following replies are typical of this sentiment:

Girl, 11. Rich people is always sickly and poor people has good health.

Girl, 12. No, because I would not be good to my little brother.

Boy, 15. No, I wouldn't do justice to every one.

Girl, 15. No, I would not like to be rich because a rich person will not enter the Kingdom of Heaven. I would rather be poor and be kind and gentle in my manner.

Girl, 16. I would not like to be rich for—

I care not for riches,
Neither silver nor gold,
I would make sure of heaven,
I would enter the fold.

Boy, 17. No, I would forget the Lord and put my whole heart and mind in my riches.

Boy, 20. I don't care to ever be rich. If I were rich it might come to me to turn to the things of the world, and not on heavenly affairs.

Bearing in mind that wealth in the Black Belt means merely a decent standard of living, we must regard the religious ban placed upon its accumulation as a positive encouragement of unthrift.

The children's record of their expenditures for one week bears out this conclusion. The average amount possessed by each of the twelve hundred children, was twenty-five cents, earned by the majority in such ways as gathering corn and hay, sailing a boat, selling oysters, papers and scrap iron, running errands and carrying packages, picking over cinders and 'writing a letter for a lady.' It is difficult for the children to account for the use of their money.

'I spen it honest,' 'I spent it for things,' 'I spent it for my use' indicate, not reluctance to divulge private affairs, but the fatal facility with which their money escapes them. Burial society dues,* school material, car rides and clothing, including such elegancies as 'a backing comb' and 'two yards of second moning' are among the expenditures mentioned. The largest item for expenditure is for dainties—candy,

* The majority of negro children in the South belong to burial societies, which, in consideration of small weekly payments, agree to furnish them a funeral with certain desirable accessories, a hearse with plumes, a specified number of carriages, etc.

peanuts, pickles, cheese and cakes—to the average amount of about four cents per child. The same average amount is temporarily kept by each child. As it is often stated, 'When I get some more to put with it I will get something I want.' The idea of putting money away for some definite future use is rarely found.

Booker Washington's 'great quadrivium' for his people consists in the arts of acquiring 'property, economy, education and Christian character.' The success of Hampton and Tuskegee lies in the habits which they form of thrift and industry, and in the new wants which their students can supply by the exercise of their trades. No graduate from either school will be contented without a home of his own, sufficiently roomy to ensure decent privacy, supplied with clean and comfortable furniture, with pictures and with books, and with a plot of land large enough for vegetables and flowers. But in the Black Belt this constitutes the wealth which is condemned by the theology of an uneducated ministry.

This theology is undoubtedly an outgrowth of slavery. It was most desirable to suppress in slaves any ambition to own property. But the great obstacle to useful citizenship to-day is this very lack of ambition. For sloth and extravagance are justified by the belief that God has placed a ban upon the fruits of industry and foresight.*

It is a significant fact that only three children find any religious sanction for accumulating property. A girl of thirteen declares that: 'The Lord put something on this earth for everyone,' and another justifies herself by the statement: 'My Father in Heaven is rich.' An Alabama boy of seventeen writes, 'I would like to be rich because I could serve God better. I wouldn't have to plow and get angry with the mules.' A girl of eighteen sends a beautiful specimen of casuistry. "I would like to be rich, then I would be able to live above wants. Though the Bible says it is impossible for a rich man to enter the Kingdom of Heaven. But I would trust God. Because there is nothing impossible with God."

The different religious teaching of city children certainly accounts largely for their different attitude towards wealth. Among the negro clergymen of the cities represented are men distinguished for broad training, for careful investigation of social conditions and for rare personal devotion. Realizing that the progress of their race depends largely upon its industrial development they constantly exalt thrift and a good standard of living in their teachings. There is no present danger that the growth of avarice will destroy the negro's religious sentiment. Sufficient to keep this alive for many generations is his

* A Georgia deacon is reported who was deposed from his official position in the church because he had acquired 10 acres of land and was therefore considered unable to 'keep his mind on heavenly affairs.'

inextinguishable brotherly love. The generosity of the Southern negro both in spirit and in deed is his most lovable trait. There is always room in the poorest cabin for the child of misfortune, and that family is a rare one which does not contain one or more adopted children—the orphaned or abandoned offspring of the unfortunate. In the hungry barren lives of these poor negro children the first thought of wealth is what it would do for father and mother or 'for my people.' Sixty per cent. of the children between fourteen and twenty, who wish to be wealthy, are actuated by thoughts of others.

The following papers are typical of this spirit:

Boy, 14. I would like to be rich so when any poor man come to my door, I would give him something.

Boy, 14. I would like very well to be rich because my father and mother would not hafter work. All they would do to eat and sleep.

Girl, 14. Yes, so I could take care of poor and motherless children.

Boy, 18. My home would be better and I would pay some of those children's tuitions who have to leave school, and I would try to make it possible for them to earn more money.

Scattered throughout the South are scores of educated negro men and women whose lives of noble devotion to their people are testifying to this spirit of brotherly love. Of inestimable value in their work would be the aid of pastors, industrially trained, who by teaching and example sanctioned 'property, economy, education and Christian character.' The inherent generosity of the negro character might easily be made the moving force in material accumulation, and so clothe it with righteousness. But perhaps the greatest foes of rational progress are the untrained preachers who destroy initiative and check energy.

This study certainly emphasizes the correctness of the statement recently made by the Hon. William T. Harris:* "The crying need at the present day is for an educated pulpit, among the colored people of the South. The majority of these ministers are illiterate and ignorant, and their congregations are filled with superstition, some acquired and some hereditary, as a characteristic of the African race."

* Quoted in Washington 'Post,' May 10, 1900, from Dr. Harris's address at the graduation exercises of the Training School for Nurses at the Freedmen's Hospital.

THE DESCENT OF MAN.

By Professor LINDLEY M. KEASBEY,
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GENERAL evolutionary evidence led anthropologists some time ago to postulate a pliocene precursor of man, but their surmise has only recently been substantiated by particular proof. The search for the so-called missing link was at first confined to the temperate zone. Many discoveries were made, but, as the skulls and implements unearthed were all taken from pleistocene deposits, there was nothing to indicate the existence of man on earth before quaternary times. It was not, indeed, until investigations were transferred to the tropics that earlier vestiges of human life were revealed. In the year 1894 Dr. Eugene Dubois discovered the upper portion of a skull and some skeletal parts of a distinctly human creature buried in the pliocene beds of East Java. These remains have since been subjected to the strictest scientific scrutiny and pronounced genuine. Taking the geological location of the discovery into account, there can be no further doubt, therefore, that in this tropical region the human species was already differentiated from the apes in tertiary times.

Judging from the size and form of the skull, and from such portions of the skeleton as remain, the variation of the human prototype, or to give him his scientific name, *Pithecanthropus erectus,* was evidently along both psychic and physical lines; the former showing a difference of degree, the latter exhibiting a distinction in kind.

There are two anatomical tests of intellectual superiority: cranial capacity and the convolutions of the brain, both of which can be applied in the present instance. It is a well-known fact that the frontal bone, which forms the vault of the anterior part of the cranium of young men and apes, is divided by a suture. So long as this line of growth remains open, the fore part of the cranium can expand; but if the anterior sutures of the skull consolidate early in life, the cranium cannot increase in capacity beyond the size reached in early infancy. In consequence of the early closure of these sutures in the anthropoid apes, the cranial capacity of these creatures is restricted, and the fore part of their brain rarely increases beyond the size attained at the end of the first year of life. With man, however, these sutures do not consolidate until a much later period, and, as the anterior lobes of the brain continue to develop, human cranial capacity increases accordingly. As a result, the average human being possesses four times as

much brain surface as the anthropoid ape. Applying this test to the human prototype, we find that Pithecanthropus occupies an intermediate position between the higher apes and modern man. That is to say: if we set specimen anthropoid skulls in an ascending series according to cranial capacity, we shall discover that between the higher apes and Pithecanthropus there is a considerable gap; Pithecanthropus is followed shortly in the scale by the Neanderthal group of men, whose skulls were found in the quaternary deposits of Europe; these in turn are succeeded by the crania of the lowest living savages; and from this point the series runs on without interruption through the various races of man to the highest existing types. Thus on the human side there is practically no break in the gradual development of cranial capacity from tertiary to quaternary, and upwards through prehistoric to historic man. The only interval that occurs is on the animal side, between the lowest type of man and the highest type of ape; from which we may infer that the pliocene precursor stood considerably above his simian relatives in intellectual capacity, though the difference was merely one of degree.

The same result is reached by a comparative study of the convolutions of the brain. It has been demonstrated that the gyri of the brains of man and the anthropoid apes are similar, with the exception of the convolutions which enter into the formation of the frontal lobes. The superior and middle gyri of these lobes are much shorter in the brains of anthropoid apes than they are in the brains of man, and in the brains of anthropoid apes the inferior frontal gyri only exist in rudimentary form. These anterior lobes of the brain, or more exactly their cortical nerve elements, to a large extent control the higher intellectual faculties. The condition of these frontal convolutions is, therefore, like cranial capacity, an index of mental endowment. Applying this test to the human prototype, we find that with respect to his cerebral convolutions, Pithecanthropus stood considerably above the other anthropoids, and within the line of development leading to the higher human types. This is proved by the impressions on the interior of the Java skull, which show that the superficies of the convolution of the prototype's brain was double that of the largest brain of any anthropoid ape, and somewhat less than half that of the brain of modern man. The convolutions themselves are also well marked and distinctly human in form. Thus whether we judge from cranial capacity or from cerebral convolutions, it is evident that the pliocene precursor was psychically differentiated from the apes and endowed with the intellectual attributes of man.

Along physical lines the modification is even more marked. From the shape of the femur (discovered in close proximity to the skull), it is evident that Pithecanthropus stood erect and walked upright on the

earth. If not already become, the prototype was, therefore, certainly in the course of becoming, a true biped, using his legs alone for locomotion and developing perfectly plantigrade feet. Freed from further service for locomotive purposes, his arms had, no doubt, become relatively short and his hands exclusively prehensile. In all these respects the reconstructed skeleton of Pithecanthropus shows a striking divergence from the characteristic anthropoid type. The apes as a group are stoop-shouldered tree-dwellers, with hands and feet primarily adapted to swinging and climbing. Even the few varieties that dwell habitually upon the ground, of which the baboon is the best example, have not lost their inherited ability to climb, while in walking these creatures have reverted to the quadruped habit. Some of the arboreal apes also come occasionally to the ground; but when they walk, these animals adopt a crouching attitude and use their arms as aids to locomotion. The gibbon is, in fact, the sole ape that walks erect, and this is only possible in his case by reason of the extraordinary length of his arms. When unconcerned this creature walks with his long arms held aloft like balancing poles and hands outstretched to grasp any overhanging support, but when frightened the gibbon likewise drops his arms to the ground and swings along between them as if on crutches. Taking structural characteristics into account, it is, therefore, possible to draw a sharp distinction between the short-legged, long-armed, stoop-shouldered, arboreal ape, and the long-legged, short-armed, erect, surface-dwelling ancestor of man.

Specific variation in the biological sense is the accomplishment of that which variability permits, environment requires, and selection directs. No stock or lineage breeds perfectly true; the line of every descent is marked by certain modifications. The general tendency of such modification is toward the preservation of the more useful and the extinction of the less useful or useless characters. Survival is thus the result of the selection of such variations as adapt the organism to its environment, the more plastic the organism the greater the possibility of variation; the more favorable the environment the higher the type of animal evolved. Attributing variability, then, to the anthropoid stock, from the fact of man's survival, we may presume that the modifications characteristic of the human species were favorable in this sense, that they adapted the pliocene precursor to his mundane environment. Judging from the further fact that the tree-dwelling apes have long since reached the stationary stage, while land-dwelling man has steadily continued to advance, we are also justified in considering the terrestrial habitat more advantageous than the arboreal abode. The descent of man appears, accordingly, to be marked by progress along the line of heredity and improvement in the way of environment, selection in this instance giving rise to a distinctly superior species.

Passing over to particulars, it is pertinent to enquire wherein this specific superiority consisted. In what respect was the erect ground-walking human prototype better fitted for advancement than his stoop-shouldered arboreal ancestors? Favorable structural and environmental variations are, generally speaking, along two lines: those that enable animals to escape more easily from their enemies, and those that place them in a better position to acquire sustenance for themselves. It is impossible to conceive that the pliocene precursor gained any advantage over his ape-like ancestors in the former direction by adopting an upright attitude and abandoning his arboreal abode; for in so doing he lost his earlier and easier means of escape through the trees, without acquiring by way of compensation any corresponding facility for taking flight on foot. The only alternative is, therefore, to suppose that the superiority of the human species was in connection with the food-quest. As far as quantity was concerned there was nothing, however, to be gained by coming down from the boughs, for the trees of the tertiary forest afforded a supply of nuts and fruits far in excess of the demand. The advantage must, therefore, have been qualitative, that is to say, in the way of a wider food-choice. As an erect, surface-dwelling creature man was evidently able to secure a greater variety of subsistence than his ape-like ancestors obtained from the trees. Being arboreal their food was confined to nuts and fruits, while by becoming terrestrial he was in a position to add roots and berries, and, in the course of time, also fish and flesh to his fare. Human progress appears, accordingly, to have been away from a strictly frugivorous in the direction of an omnivorous diet. A similar tendency is observable among the other anthropoids. The arboreal apes, for instance, are naturally frugivorous, but when taken from the trees and bred in captivity they readily become omnivorous. The semi-terrestrial types exhibit the same proclivities in their wild state. The gorilla, for example, usually lives on fruits, but also eats birds and their eggs, small mammals, reptiles and the like, and has even been observed to devour large animals when found dead. What is only an incipient tendency among the apes probably became an habitual practice with the ancestor of man. The superiority of the human being may thus be said to have consisted in the acquisition of qualities and the occupation of an environment which enabled him to widen the range of his food-choice.

It is evident enough that the variation of environment was favorable in this respect, for the terrestrial habitat certainly offered boundless opportunities for the development of an omnivorous taste; but it is not so easy to see how the characters we have described as human rendered these opportunities available. Berries and roots were plenty in the woods, the streams were alive with fish, and the tertiary forest

abounded in game of all sorts; but the superficial food-ground was already preempted by other animals, which were not likely to allow man to encroach upon their subsistence without a struggle. Adaptation to the new surroundings must consequently have been effected at the expense of a conflict with the former lords of the forest. But the human prototype does not appear to have become fitted for such a contest either through heredity or environment. From his ape-like ancestors the pliocene precursor merely inherited a large cranial capacity and the ordinary anthropoid characters; while in adapting him to the terrestrial habitat, selection simply set him upright on his feet and accorded him the free use of his arms and hands. Leaving aside his inherited endowment for the moment, the structural modifications that occurred during the period of specific differentiation seem at first sight to have set man at a positive disadvantage over against the frugivorous apes, on the one hand, from whom he descended, and the land-dwelling carnivora, on the other, with whom he had henceforth to contend. The food of frugivorous creatures remains fixed in its place and only requires to be plucked. These animals have, therefore, no need of powerful prehensile organs in attack, while for defense they usually rely upon their locomotive organs in flight. The prey of carnivorous creatures has, on the contrary, to be caught and killed, and on this account these animals are supplied with vigorous attacking organs, which in times of necessity may readily be employed for defense. The apparent anomaly in man's case is that in becoming terrestrial, he lost his former facility for climbing and making his escape through the trees, without by way of compensation acquiring sufficient strength or agility to cope with the land-dwelling carnivora. Cut off from escape above and surrounded with animal enemies below, physically unfitted to lie in wait and spring, having neither claws nor talons wherewith to grasp and hold, and not being fleet enough either to take flight or to follow fast on foot, how then was it possible for man to gain his acknowledged ascendancy over the beasts?

As a group the anthropoidea are structurally adapted to two sets of physical exercises: swinging and climbing, and striking and throwing. In a more restricted sense, however, the two practices are incompatible, for skill in one direction can only be acquired at the expense of proficiency in the other. For the former exercises, moreover, instinct alone is sufficient; while for the latter a certain amount of ingenuity is required. Being arboreal, swinging and climbing are essential to the frugivorous apes, both for food-getting and for flight, and on this account their instincts are set and their organs especially adapted to this purpose. Those that come occasionally to the ground in search of other aliment are, however, also able after a fashion to strike and throw. Both the gorilla and the chimpanzee, for example, are in-

genious enough to swing sticks, and the orang will break off branches and fling them at his tormentors or hurl the thick husks of the durian fruit. Nevertheless, striking and throwing are exceptional even with the semi-terrestrial apes, or at most only occasional exercises with such as have sometimes to defend themselves upon the ground. But for man the conditions were reversed. After the human prototype had parted company with his arboreal fellows to become a land-dwelling creature, swinging and climbing were no longer essential to his success. Henceforth he had to win a place for himself on the ground, and lacking natural means of attack and defense, in the course of his contest with the carnivora, he was compelled to exercise ingenuity in the choice of artificial implements and develop his incipient capacity to strike and throw. It is not so strange, therefore, as it at first sight appeared, that in adapting the human prototype to his earthly environment selection should have simply set him upright on his feet and accorded him the free use of his arms and hands; for, with his inherited mental endowment, these slight structural modifications were just such as were necessary to make him a weapon-wielding animal and so set him above his enemies.

But besides becoming psychically and physically fitted for striking and throwing, man's faculties had also to be trained before he could acquire proficiency in the art of weapon-wielding. To deal a straight blow with a club, or hit a distant mark with a missile, it is necessary to take accurate aim; and this involves the development of a good eye. Heredity favored the human prototype in this respect, for his ape-like ancestors had for centuries been accustomed to rely upon their sense of sight in their search for subsistence. In developing his incipient capacity to strike and throw, the pliocene precursor had, therefore, simply to turn his inherited acquisitive sense to the additional service of distance-determining and range-finding. Long practice and hard training must, nevertheless, have been necessary before primeval man acquired the knack of aiming accurately. The semi-terrestrial apes, whose instincts are still set and whose organs are primarily adapted to swinging and climbing, have never acquired any special facility in this direction. With the exception, indeed, of the land-dwelling, tree-climbing baboon, who is apparently able to hurl branches and hard clods with considerable dexterity, they all exhibit a ludicrous lack of skill in striking and throwing. On the other hand, by dint of observation and imitation, the small boy of our day soon learns to take accurate aim, and savages without exception show surprising skill in this direction. Considering the necessity of the case, and judging from the fact of human survival, it is extremely probable, therefore, that in the course of his contest with the carnivora the prototype acquired the knack of aiming accurately and eventually became an adept in the art of weapon-wielding.

The keen eye that the human prototype inherited from his ape-like precursors was also useful to him in other ways, for food-getting, path-finding and perceptive purposes in general. In some respects, indeed, sight may be regarded as the most serviceable of all the senses. Touch and taste, upon which the lower orders of life rely, require actual contact with the objects to be distinguished, and, consequently, only afford a concept of the immediate environment. Hearing and smell predominate among the vertebrates, have a broader range and are especially useful in this, that they allow the mind to distinguish particular sounds and odors from surrounding conditions, and so afford a perception of the local environment. The sense of sight offers still further advantages in that it conveys a concept of the special as well as of the universal environment and allows the mind not only to distinguish particular objects, but also to compare them with each other and so form a general conception of the outer world. Sight has this disadvantage, however: it only gives instantaneous information from one quarter, and necessitates a turning of the head or body to take in surrounding conditions, because light travels only along straight lines; whereas hearing and smell accord instantaneous information from all quarters, because sounds and odors disseminate in every direction from the center of disturbance. Thus though primeval man might well enough have relied upon his sense of sight exclusively for acquisitive purposes, defense demanded that he develop a sentinel sense besides. Heredity also determined this choice. Like the other anthropoids, man continued to rely upon his hearing to warn him of danger approaching from behind. Thus beside becoming adapted to walking and weapon-wielding, we may imagine the human prototype developing during the process of differentiation which fitted him for his mundane career, the keen eye and acute ear that had been handed down to him through heredity from his ape-like ancestors.

Working upon the biological principle of variability and following the interaction between heredity and environment, by a process of reconstruction we have been able to form a tolerably complete conception of the original condition of man. He was evidently a land-dwelling, omnivorous, weapon-wielding animal. For this manner of life he was psychically and physically fitted during the process of specific differentiation. From his ape-like ancestors he inherited his prehensile hand, his keen eye and his acute ear; in adapting him to the earthly environment selection increased his cranial capacity, developed the convolutions of his brain, set him upright on his feet and accorded him the free use of his arms for acquisitive purposes. Thus endowed, primeval man was evidently enabled to cope successfully with the carnivora, and eventually make himself master of the forest.

Taking the geological location of the remains of Pithecanthropus

into consideration, we concluded that the differentiation of the human species took place during tertiary times. Reasoning in like manner from the geographical situation of the discovery, we may suppose Indo-Malaysia to have been the cradle-land of mankind. The assumption is further substantiated by the fact that this tropical region is still the home of many of the higher apes, and was probably the point of departure for the dispersion of the other anthropoids. If we turn, now, to the evidences of quaternary culture we shall find a multitude of human relics buried in the pleistocene or post-pleistocene deposits of every continent of the globe. The widespread diffusion of these remains proves beyond peradventure the existence of man in every quarter of the earth at the beginning of the prehistoric epoch. Obviously, then, the descendants of the pliocene precursor must have wandered far and wide from the original abode during the long geological era that elapsed between the pliocene and post-pleistocene periods. It is incumbent on us, therefore, to determine how this migratory movement was effected. Close upon the problem of the differentiation of the human species comes, in other words, that of the dispersion of mankind over the face of the earth.

Subjectively speaking, there were evidently no difficulties in the way. The human prototype was, as we know, structurally fitted to walk, and his omnivorous manner of life must in itself have led him further and further forth in search of subsistence. In so far as physical capacity and psychic motive are concerned we may, therefore, think of the pliocene precursor as an ambulatory, omnivagant animal. It is only when objective conditions are taken into account that obstacles appear to arise. Granting primeval man's ability and desire to wander, how are we to imagine he endured the vicissitudes of climate that met him on the march? and how are we to suppose he crossed the seas that separate the several continents? Before the great antiquity of the human race was assured, it was necessary to assume an almost miraculous power of adaptation on man's part, and furthermore to endow him, somewhat inconsequently, with an innate knowledge of navigation; but now that science has succeeded in tracing man's ancestry back to tertiary times, we may more logically accept the explanation that geology affords. Instead of proceeding upon the presumption that the climate and configuration of the earth was then as it is now, we must reckon with the geological changes that have since occurred and work out our conclusions accordingly. In so doing we shall find that during these early ages of his existence on earth, environmental influences opposed no insuperable barriers before the dispersive propensities of man.

If, as we have supposed, the prototype was differentiated from the apes in Indo-Malaysia during the pliocene period, and arrived in re-

mote regions of the earth before the prehistoric epoch, the dispersion of the human race must have been coincident with the ice age. It is with the climatic and topographic condition of the glacial period, therefore, that we have to do in determining the original routes of migration. According to the astronomical explanation of glacial phenomena, which best accords with the geological facts as far as they are known, the Northern and Southern Hemispheres were alternately subjected to frigid conditions. Owing, however, to the disposition of the land-masses of the globe, glacial influences were more widespread in the north than in the south. When the glaciers proceeded from the arctic regions, the climate of the northern continents grew cold, the thermal equator moved somewhat south of the geographical equator and the southern peninsulas became predominately tropical. When, on the other hand, the ice advanced from the antarctic regions, the highlands of the southern peninsulas were glaciated, and, as the thermal equator moved north of the geographical equator, the northern continents enjoyed an equable climate, ranging from tropical to temperate conditions and devoid of great seasonal variations. Several such glacial cycles appear to have elapsed during quaternary times. After the third advance of the ice from the north, however, the glaciation of the hemispheres became less severe and the genial conditions more permanent, until, towards the end of the great ice-age, the glaciers were confined to the arctic and antarctic regions, and the globe became divided as at present into temperature zones.

As the ice advanced for the first time from the arctic regions, the temperature of the Northern Hemisphere became gradually colder, until during the early part of the pleistocene period, continental glaciers spread down over central Europe and North America. The increasing frigidity of the Eurasian continent at this time was doubtless sufficient to deter dispersion from the Indo-Malaysian cradle-land towards the north. Mountain ranges also hindered progress in this direction, for the Himalayas must have acted as a barrier towards Asia and tended to deflect the lines of migration east and west along the central latitudes. Immediately preceding and during the first glacial epoch, therefore, climatic and topographic influences combined to confine the original course of dispersion within the Indo-Mediterranean-Malaysian belt and the lower peninsulas of the Old World. This southern portion of the Eastern Hemisphere, it should be noticed, is separated from the northern continental area by a broken mountain range, running from the Himalayas to the Pyrenees. These mural masses protected the low-lying lands along the southerly slopes of the mountains from the increasing cold of the glaciated north, so that in spite of the fact that the thermal equator ran somewhat south of the geographical equator at this time, tolerable climatic conditions prevailed everywhere below

the Himalayan line. In these early days, moreover, the penisula portion of the Old World constituted a practically continuous land-mass. Toward the west India was connected with Africa, and Africa was joined to Europe by two or more isthmuses. In the opposite direction, the Malaysian peninsula was extended toward Australia through what are now the separate islands of Sumatra, Borneo and Java; Australia was likewise connected with New Guinea, and the immense island continent thus constituted was to all intents and purposes coterminous with the southeasterly extensions of Malaysia. It must have been possible, therefore, at this time for primeval man to proceed from the Indo-Malaysian abode along the central latitudes, to the Atlantic on the west, and far out across the Pacific on the east, without having to cross the open seas.

During the course of the pleistocene period the ice disappeared from the north and glaciation set in from the south, the glaciers in this instance proceeding from the antarctic regions and from the highlands of the southern peninsulas. The thermal equator also moved north of the geographical equator at this time, and during the long interglacial epoch that followed, lasting at least ten thousand years, the whole Northern Hemisphere enjoyed an equable climate, ranging from tropical to temperate conditions and devoid of great seasonal variations. The effect of this change must have been to limit the lines of migration toward the far south, and greatly to extend the course of dispersion towards the northeast and northwest. Or to put it more exactly: entry into South Africa was probably barred by the increasing cold, but as the influence of the southern glaciers did not extend as far north as the Indo-Mediterranean-Malaysian belt, the inhabitants of this region were doubtless free to wander east and west as before along the central latitudes. Nor did climatic conditions any longer prevent men from penetrating into the continental area beyond. Mountain masses still barred the way in the center, to be sure; but passages were open on either side; from the Mediterranean region into Europe, and from the Malaysian region into Asia. Above the Himalayan line the Tibetan plateau interposed itself between these Mediterranean and Malaysian emigrants and probably kept them for long ages apart. For this reason, and doubtless also because the maritime regions offered greater attractions to primeval man than the inland areas, the earliest lines of migration appear to have followed the Atlantic and Pacific coasts of the Eastern Hemisphere into the northern latitudes, where the shore lines of the Eurasian continent stretch out toward America. During the first and second interglacial epochs the two hemispheres were, indeed, practically coterminous in these parts. This was due to the fact that the level of the northern oceans was lowered at these times, leaving land-bridges exposed to view which have since become covered by the sea. As a result, the

Atlantic and Pacific routes of migration were continued along the northern latitudes into the Western Hemisphere. Toward the northwest, the British Isles then formed an integral part of the European continent, and from this peninsula, land-connections were in all probability extended through Iceland and Greenland to America. In the far northeast, Asia was likewise joined with America by what geologists call the Miocene bridge, which probably lasted into quaternary times; and after the Behring strait finally broke through, the Aleutian island chain still linked the two continents together along the Pacific. As far as climate and topography were concerned, during these interglacial epochs there was nothing, therefore, to prevent the Mediterranean and Malaysian emigrants from pushing northwestward through Europe and northeastward though Asia into America.

As the glaciers advanced successively from the arctic and antarctic regions, the climate and topography of the Northern and Southern Hemispheres varied in this way at least three times. After the third glacial epoch, however, the changes were less marked, until towards the close of the ice age, the configuration of the earth gradually assumed its historic form and the globe became divided as at present into temperature zones. The possibilities of dispersion during the glacial, interglacial and post-glacial periods may, accordingly, be generalized as follows: Each time the Northern Hemisphere was glaciated, the migrations of men must have been confined for the most part within the Indo-Mediterranean-Malaysian belt and the southern peninsulas of the Old World. During the genial epochs that intervened between the three great glacial movements from the north, the continental area was open to incursion on either side, the climate of the Northern Hemisphere was everywhere equable, and the topographic conditions were such as to encourage migration along the Atlantic and Pacific shores of the Eurasian continent into the arctic peninsulas of the New World. As the arctic glaciers became more and more restricted to the northern regions, primeval men were probably able to hold their own in the continental area and migrate east and west across Eurasia. But after the third glacial epoch, if not before, the Atlantic land-bridge was broken; so that henceforth access to America was only possible along the Pacific, by means of the Aleutian island chain.

Cave deposits, kitchen-middens and fossil remains mark the course of the dispersion of mankind in these different directions. The aboriginal inhabitants of the now separated continents and isolated islands of the globe also preserve certain distinguishing characteristics by which the lines of their respective ancestries can be traced back along these several routes to more or less definite points of departure about the Indo-Malaysian abode. There is archeological and ethnological evidence, therefore, to show that primeval men migrated

originally along the lines laid down by the climate and topography of the glacial periods. But these indications of the actual courses of migration are beyond the range of the immediate enquiry, and should, therefore, be reserved for separate consideration. It is sufficient for the present to have pointed out the possibilities of dispersion, which may be summarized in conclusion as follows: From the skeletal parts of Pithecanthropus we are assured that the pliocene precursor could walk; the nature of his food-quest affords the wandering motive; the widespread diffusion of quaternary culture convinces us of the fact of dispersion; and the data of geology define the routes provided by nature for the original migrations of mankind.

DISCUSSION AND CORRESPONDENCE.

THE FUNCTIONS OF A MUSEUM AND OF ITS DIRECTOR.

To the Editor:—Professor E. Ray Lankester, director of the Museum of Natural History, London, concluded an address on 'The Scope and Functions of Museums' at the opening of a new wing of the Ipswich Museum on November 8 with the following words:

> A county museum is not a place for children or school-teaching: it is not Noah's Ark or Madame Tussaud's waxworks, but a place for the delight of grown-up men and women. It should be full of the things which are the pride of those who care for the history and natural life of their countryside, and just as you do not use a picture gallery to teach the elements of drawing, but for the enjoyment of fine pictures, so your county museum must be for the enjoyment by your grown-up, educated people of the rarities of nature and of art, and not for the cramming of schoolboys and schoolgirls.
>
> If a local museum is a place no better for school teaching than Madame Tussaud's 'chamber of horrors,' or if it only serves for the cramming of school-boys, so much the worse for the museum and its director. Neither has Professor Lankester a very high opinion of adult visitors, for in the same address he calls them 'innocent' and 'casual well-meaning.' Such sarcasm and assumption of superiority ill befits the director of a museum.
>
> Surely a man who accepts a position such as the directorship of the British Museum of Natural History or the secretaryship of the Smithsonian Institution owes a definite duty to the public, and should not permit his impressions of his own dignity to interfere with the services for which he is paid.
>
> Can you not, sir, secure for your excellent journal an article on 'The Scope and Functions of a Museum Director'?

A TEACHER.

SCIENTIFIC LITERATURE.

RECENT PSYCHOLOGICAL BOOKS.

THE 'Dictionary of Philosophy and Psychology,' edited by Professor J. Mark Baldwin and published by the Macmillans, is a work of magnitude and importance. Only one of the three volumes has as yet been issued, but it suffices to give a correct impression of the character, range and quality of the undertaking. It falls between a dictionary and an encyclopedia, and in rather an eclectic fashion, some of the articles treating a small topic concisely while others fill many pages. In a first attempt of this character, with assistant editors and contributors scattered all over the world, it was obviously impossible to secure complete uniformity, and the frequency with which the editor's initials occur indicates that he realized the need of securing a unitary point of view. It is evident, however, that there is less agreement as to the fact and theory among philosophers and psychologists than is the case in other sciences. All the more credit must for this very reason be given to editor, contributors and publishers for producing what will for many years be the standard reference work in philosophy and psychology.

The French excel in the production of year-books, and 'L'année psychologique,' of which the seventh volume has recently been issued, is one of the best of them. The preparation must involve great labor on the part of the editor, M. Binet, for the researches, filling 558 pages, come chiefly from his laboratory at the Sorbonne, and the reviews, filling about 150 pages, are nearly all written by his own hand. The bibliography, containing 2,627 titles, is, however, reprinted from that of the 'Psychological Review,' and we fail to find reference to this fact. As there is no psychological journal in France, this work is essential to those who wish to follow the progress of experimental psychology in that country.

M. Pièrre Janet's 'Etat mental des hystériques' was translated into English by the late Mrs. Hiram Corson and is now published by the Putnams. The book appeared in French some nine years ago, and the need of the present English version is not quite obvious. It was sufficiently accessible to scientific men in the original, and it is to be feared that if the thousand copies which American publishers regard as the minimum sale that warrants acceptance are distributed, they will fall chiefly into the hands of those whom the translator call 'hystericals.' M. Janet has made some careful observations, and in his explanations lays great stress on subconsciousness, split-off ideas and the like. The French have done so much more work in these directions than others that we should perhaps accept their theories. But conservative scientific and medical men prefer to wait.

'Intuitive Suggestions,' by Mr. J. W. Thomas, bears the respected imprint of Messrs. Longmans, Green & Co., and opens the question as to whether publishers accept any responsibility for their books, beyond the financial one. The author places on his title-page the text: 'And God said, Let there be light; and there was light.' We fear not, if the reference is to the contents of the book. The author expects London business men to soar 'above the smoke and din to seek their homes in the country,' not in flying machines but by 'levitation.'

THE PROGRESS OF SCIENCE.

THE CARNEGIE INSTITUTION.

ONE of the most noteworthy events in the history of science was the bequest of James Smithson, an Englishman dying in Italy, in 1829, of about $500,000 to found at Washington 'an establishment for the increase and diffusion of knowledge among men.' Equally important is the gift of Mr. Andrew Carnegie of $10,000,000 to establish in Washington an institution for the encouragement of 'investigation, research and discovery.' These two foundations represent more than an addition to the sum annually spent on scientific work. They stand for the spirit of science, not confined by place or buildings, titles or degrees. In foreign countries we are often called worshipers of wealth and ostentation; in reply we need only point to the Smithsonian and Carnegie institutions, situated in the national capital, but extending throughout the country and beyond, quietly and powerfully representing the highest ideals of knowledge and research.

The Smithsonian Institution under Henry and Baird fostered science in many directions, having been more or less a factor in the establishment of the National Library, the Weather Bureau, the Geological and Coast Surveys and the Fish Commission. It still has under its charge the National Museum, the Bureau of American Ethnology and the Zoological Park. The Carnegie Institution with twenty times the resources of the Smithsonian will henceforth be a great influence for the advancement of knowledge. The founder states that the primary object is the promotion of research, and specifies several directions in which work will be undertaken. The Institution will probably supersede the Washington Memorial Institution in the function of utilizing for advanced work the resources of the government at Washington and elsewhere. It will also aim to increase the efficiency of universities and other institutions by providing funds for investigations and for fellowships. It will assist in the publication of scientific work. It may give salaries and pensions to permit the continuous prosecution of research. Mr. Carnegie shows much insight in particularly specifying as one of its objects 'to discover the exceptional man in every department of study, whenever and wherever found, and enable him by financial aid to make the work for which he seems specially designed, his life work.'

This is, indeed, the great need of science—to find the men. Given the man and there is no danger but that the research, the discovery and the publication will follow. What is essential is to secure for research the men best fitted for it. Good men are needed for all kinds of useful work; but on the whole the business man, the lawyer or the physician is less likely to contribute to the general welfare than the investigator. But the investigator is exactly the man whose profession is most insecure. He never depends on his scientific work for his support; he must earn his living by teaching, by administrative work or the like. A good novel or a good picture has market value, a good research has none. The author is not only unpaid, but is fortunate if his paper or book can be properly published without expense to himself.

The number and quality of men engaged in scientific work can apparently

be increased best in two ways; by permitting a larger number of young men to carry on work long enough to be eligible for national selection, and by offering certain prizes for those who reach the highest efficiency. Our universities now provide a considerable number of scholarships and fellowships; they should be increased, but even more than these we need offices, such as the secretaryship of the Smithsonian Institution, that will attract young men to science as a profession and provide adequate rewards and the best opportunities for those whose work is most fruitful. It has already been pointed out in these columns that while a lawyer may become a judge, a clergyman a bishop, a business man a millionaire and the like, there are no similar rewards for a scientific man or a university professor. At a comparatively early age he receives the maximum salary of from three to five thousand dollars, and no further advancement is possible—unless he leaves scientific work to become an inventor or a college president.

The directorship of the Carnegie Institution will be one prize, but its duties will be largely administrative. The trustees of the institution selected by Mr. Carnegie are men of tried administrative ability; but they are too busy and too widely scattered over the country to attend to the details of the scientific work of the institution. We should view with much satisfaction the establishment of a board of scientific directors who should at the same time be research professors, spending part of the year at Washington and part at their present universities or institutions, receiving ample salaries and having the best facilities for work. The honor of selection for this position and a salary comparable to that which may be earned in other professions would add great attractiveness to science as a profession and serve as a continual stimulus to scientific research.

There are, however, many ways by which the great resources of the Carnegie Institution can be utilized for the benefit of science, and the trustees are certainly competent to select the best methods. There is no doubt but that the institution will greatly aid in giving the United States a leading place among the nations that are contributing to the advancement of science, and will tend to make Washington one of the three or four chief scientific centers of the world.

MEETINGS OF SCIENTIFIC SOCIETIES.

THE meeting in Chicago at the beginning of the year of the American Society of Naturalists and of the national societies devoted to the biological sciences was of more than usual interest. It marked the establishment of convocation week. At the instance of the American Association for the Advancement of Science our leading universities have set aside for the meetings of scientific and learned societies the week on which the first day of January falls, greatly facilitating those meetings of scientific men, which are among the most potent factors in the advancement of science. The meeting at Chicago was also noteworthy because it was the first to be held west of the Atlantic seaboard. It will be remembered that the American Association met this year for the first time west of the Mississippi, and our two great scientific societies and centers of affiliation have thus in the same year become truly national in character. The remarkable development of science in the central states within recent years is witnessed by the fact that the meeting at Chicago was the largest and probably the most important ever held by the affiliated societies. There were over 300 scientific men in attendance, and over 250 scientific papers were presented. It is of course impossible to give here any adequate account of this great mass of scientific work. The annual discussion, in which Professors Minot, Davenport, McGee,

Trelease, Birge, Forbes and Cattell were the speakers, considered the interrelations of our scientific societies. There was a consensus of opinion that we should develop local centers for scientific meetings, but must have also national societies, and that these should be united in a great association representing the whole country and all the societies. The practical outcome was the decision of all the societies to meet next winter in Washington.

With the American Society of Naturalists met at Chicago the national scientific societies devoted to morphology, physiology, anatomy, bacteriology, psychology and anthropology. The American Chemical Society met at the same time at Philadelphia with an attendance of over two hundred and a full program. The Society now contains over 2,000 members, and is perhaps the strongest and best organized of our special scientific societies. It conducts an excellent journal, has numerous local branches which hold frequent meetings, and is affiliated with the American Association. At the recent meeting Professor F. W. Clarke gave the presidential address, dealing with the outlook for chemistry in the future viewed in the light of the past, and Professor C. F. Chandler lectured on the electrochemical industries of Niagara Falls. The Geological Society of America also met during convocation week, the place being Rochester, N. Y., and the time December 21 to January 2. The president, Dr. Charles D. Walcott, gave an address on 'The Outlook of the Geologist in America,' and the program contained the titles of some thirty papers. The Astronomical and Astrophysical Society of America met at Washington, while the American Mathematical and Physical Societies and the Society for Plant Morphology and Physiology of the Eastern States met in New York. All these societies will meet next winter with the American Association for the Advancement of Science at Washington during convocation week, where there will be a congress of American scientific men surpassing in size and importance all its predecessors.

WIRELESS TELEGRAPHY.

As all our readers know from the daily papers, Mr. Marconi has succeeded in transmitting wireless signals across the Atlantic from Cornwall, England, to St. John's, Newfoundland. The electrical waves were received at St. John's by a long wire suspended by a kite and by means of a telephone, presumably through the mediation of a coherer. A detailed description of Mr. Marconi's latest apparatus has not been published. However, some results obtained by him several months ago show that his apparatus has been improved in its selective action, and this latest achievement shows that little remains to be done in the way of increase of power. Nevertheless there seem to be decided limitations to the utilization of wireless telegraphy; it is at present much slower than the standard Morse apparatus using a wire, the receiving operator cannot interrupt the sender but must wait patiently until the message is finished, there is no assurance of secrecy, and but one system can be operated at a time within the limits of its range.

A map of the world showing all cable connections is a very complicated affair, and the supplanting of these cables by wireless apparatus is out of the question, at least until the Marconi system is evolved into something very different from what it now is. The facts may be made clear by an acoustical analogy. The ordinary confusions of sounds in a stock exchange is bad enough, but if the manifold and characteristic shadings of voice were reduced to a monotony of mere clicks and if the resolving or selective power of the listener's ear were at the same time reduced many thousands of times the confusion would become hopeless indeed. The loudness of each speaker

would have to be reduced, and each speaker and his listeners would have to occupy a certain space to the exclusion of all others. Under these conditions a given speaker's demonstration of his power to make himself heard over a distance of many miles would scarcely be looked upon as of practical importance, unless indeed it were seriously questioned whether his associates might have the right to restrict the exercise of their vocal powers. The proper field of wireless telegraphy appears to be the overspreading of limited areas, especially areas of water, with telegraphic facilities.

AS SEEN IN GERMANY.

THOSE who wish to know something of the educational (educational in the broadest sense of the word) advantages enjoyed by the eastern United States can not do better than to consult Dr. A. B. Meyer's memoir on the museum of this section. Dr. Meyer came here in the summer of 1900 to obtain all possible information concerning our museums, their construction, arrangement, methods of installation, and the scope of his inquiries was extended to libraries and art museums. The results of his observations are being published by the Royal Museum of Dresden and the second part of the memoir, for it amounts to that, has recently been issued and comprises one hundred quarto pages with fifty-nine illustrations. It is devoted to the museums, libraries, Art Institute and University of Chicago, and Chicago has every reason to feel gratified at the showing made in this paper. At the head of the text stands Chicago's motto 'I will' (*Ich will*), and Dr. Meyer has frequent occasion to refer to the energy and creative power of this million-inhabited city, if one may paraphrase the author, of the west. In fact we doubt if many in Chicago, to say nothing of those living in other portions of the United States, realize the rapid strides she has made in—using the term in its widest sense—great educational institutions. Like the former part this gives a brief history of each institution considered, its origin, aims, endowment, expenditure, and the methods by which it endeavors to accomplish the desired ends. Then follows a detailed account of the collections, be they of natural history, art or books, with special notice of any original or important device for installation, labeling or cataloguing. As Dr. Meyer is not only a museum director, but one acquainted with the mechanical details of the various branches of work, and one who has devoted much time and thought to the construction of cases and methods of installation, he here speaks by the book.

The illustrations show an exterior view of each of the buildings considered, and noteworthy features of the interior, as well as of special cases and fittings. There are also in most instances plans giving the arrangement of the various floors, and sections showing special modes of heating or ventilating, and of the construction of modern iron frame buildings.

Dr. Meyer considers that the existence of the Field Columbian Museum should stimulate rather than deter the growth of the collections of the Chicago Academy of Sciences, and that not only do these two institutions supplement one another, but that two museums are a necessity for a city which like Chicago covers an area of 180 square miles. The plans for the Academy of Sciences are well conceived, and it would be well to consider them carefully in the event of erecting a new and permanent building to replace the present Field Columbian Museum. As we all know this was taken for a museum in default of any other available building, and Dr. Meyer may well criticize its halls as being on too large a scale to fit them for the best arrangement of a museum. One of the results of this is to bring about a somewhat heterogeneous arrangement of the

collections and to place in juxtaposition, or to include in one view through lack of division, very different classes of objects. It is hoped that the time may soon come when less money shall be spent on specimens for exhibition and more in research and publication. Beyond a certain point the mere exhibition of material can not be advantageously carried, for the confusion of mind created by a multitude of objects defeats the educational effect which a museum should exert.

The libraries of Chicago—the John Crerar, the Newberry and the Public Library—are looked upon as sustaining much the same relations to one another as do the museums, each having its own field, and one supplementing the other, while the friendly rivalry between them is resulting in the accumulation of a vast number of books and pamphlets. The combined entries of these three libraries now amount to 650,000, and at the present rate of growth, they will, in twenty-five years, reach a million, the present size of the library of Berlin, which ranks third among the great libraries of the world.

One quarter of the present volume is devoted to the University of Chicago, treating in detail its many peculiar and progressive features with special reference to its museums and laboratories. In the former the inclusion of paleontological collections with those illustrating the modern life of the globe is regarded as an excellent feature, and this is no doubt true to a great extent. Still such a union is much more feasible in a small than in a large museum and also much depends upon the point of view, upon whether it is desired to show the relations of all living things to one another, or the successive faunas and floras of the globe and the steps by which the existing order of plant and animal life has been reached.

In conclusion Dr. Meyer pays an eloquent tribute to Chicago, for which he predicts a great future as a center of science, literature and art.

IMPORTANT PALEONTOLOGICAL DISCOVERIES.

THE origin of the proboscideans, the Mammoth, Mastodon and Dinotherium, has long remained an unsolved problem, and until recently no form was known below the lower Miocene. Señor Ameghino thought he had discovered the ancestor of the group in the Santa Cruz formation of Patagonia, but his views were not shared by others, and the late Professor Cope believed, with much to support the belief, that the founder of the family would be found in Asia.

During the summer of the present year Dr. C. W. Andrews, of the British Museum, was engaged in collecting in the Fayûm, Egypt, obtaining numbers of vertebrates from deposits believed to be of Eocene or Oligocene age, most probably the former. Among the mammals represented was a small and primitive species of Mastodon, named *Palæomastodon beadnelli*, characterized by the simple structure of the last grinder and by the fact that no less than five teeth were in use at once on either side of the lower jaw. Other known species of Mastodon have but three teeth in use at any one time on either side of the lower jaw, so that this indicates an animal of a much more generalized type. More than this, Dr. Andrews obtained numerous specimens of another animal, named *Moeritherium*, about the size of a large tapir, having large and tusk-like incisors and molars, whose structure suggests that of the teeth of the Dinotherium. This creature Dr. Andrews considers to be the long sought ancestor of the Mastodon type of proboscideans. The fauna of these Egyptian beds is quite different from that of deposits of corresponding age in Europe, and the few species so far discovered hint that a more complete knowledge will throw much needed light on many obscure questions in geographical distribution. The indications are that prior to the Miocene southern Africa was an exten-

sive and isolated continental area, or, that at least it had no connection with Europe.

In the United States particular attention has been given to working out the pedigree, in the fullest sense of the word, of the horse, and in doing this the American Museum of Natural History has been especially favored by the gift of a considerable sum of money for that purpose. Under the direction of Professor Osborn parties have been successful in Texas and northeastern Colorado in obtaining unusually complete specimens of early horses. In the former locality Mr. Gidley discovered the fossil remains of a small herd of Miocene horses of the genus *Protohippus*, while in Colorado Messrs. Matthew and Brown obtained very complete specimens of Anchitherium from the Upper Miocene associated with at least three species of horse-like animals that represent side branches of the equine tree. The disappearance of horses from North America is a very singular fact; they developed here, literally growing up with the country, and they ranged from the Atlantic to the Pacific and from Alaska to Patagonia. It is even probable that they migrated to Asia at the time the Mammoth was making his way eastward, and yet they disappeared completely. It would seem that Dr. Jordan's three laws of distribution need the addition of another to explain the dying out of animals. It can not be said that a series of species that developed in a given region was not adapted to it, and the rapid increase of horses that run wild on the pampas of South America and the plains of the west shows that the modern horse was perfectly fitted to those regions.

One more important discovery during this year was the finding by Mr. Barnum Brown, while collecting for the U. S. National Museum in the Trias of Arizona, of plates of a huge labyrinthodont, at least as large as those European species restored by Waterhouse Hawkins in the likeness of gigantic frogs, for their tails were not then known. The specimens have been identified by Dr. Fraas as belonging to the genus *Metopias*, and he regards this of special importance as showing that the beds in Arizona correspond to the historic Keuper of Europe, that genus of amphibians being confined to that formation.

SCIENTIFIC ITEMS.

We regret to record the deaths of Mr. Clarence King, the eminent geologist; Sir William MacCormac, the British surgeon; Professor Aleksandr Aleksandrovic Kovalevskij, professor emeritus of zoology at the University of St. Petersburg, and Dr. Arthur König, associate professor of the physiology of the sense organs at the University of Berlin.

The newly elected presidents of the scientific societies, whose meetings are described above, are as follows: The American Chemical Society, President, Ira Remsen, Johns Hopkins University; American Society of Naturalists, Professor J. McKeen Cattell, Columbia University; American Morphological Society, Dr. H. C. Bumpus, American Museum of Natural History; American Physiological Society, Professor R. H. Chittenden, Yale University; Association of American Anatomists, Professor G. S. Huntington, Columbia University; American Psychological Association, Professor E. C. Sanford, Clark University; American Society of Bacteriologists, Professor H. W. Conn, Wesleyan University; The Society for Plant Morphology and Physiology, Professor M. V. Spalding, University of Michigan; The Geological Society of America, Mr. H. N. Winchell, Minnesota.